

# SCIENCE

AUGUST 18, 1950

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USE OF BLOOD GROUPS  
IN HUMAN CLASSIFICATION

WILLIAM C. BOYD

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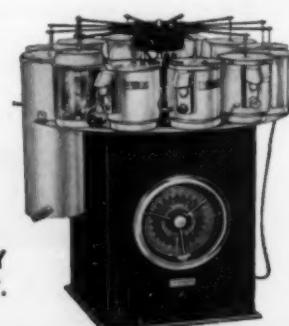
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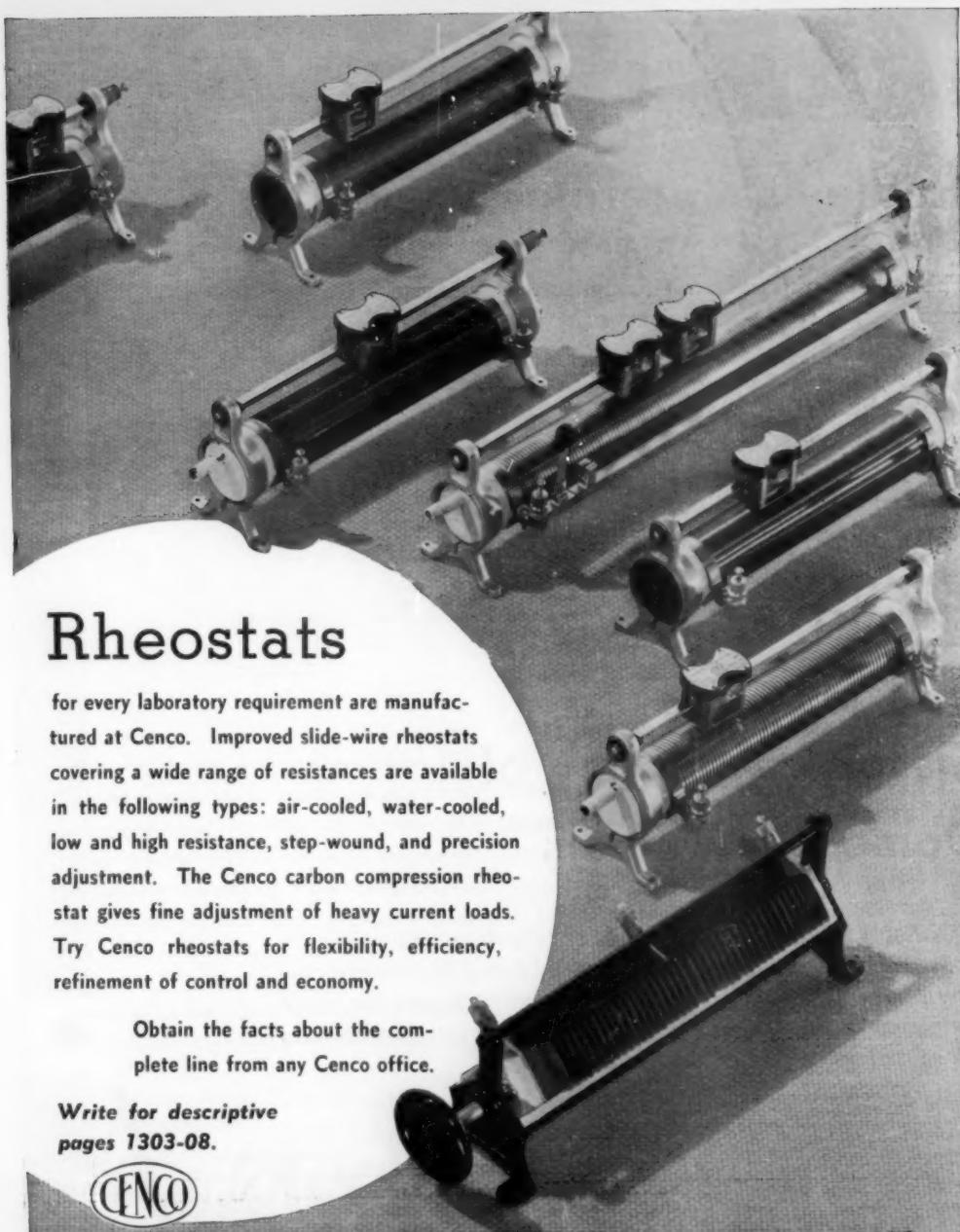
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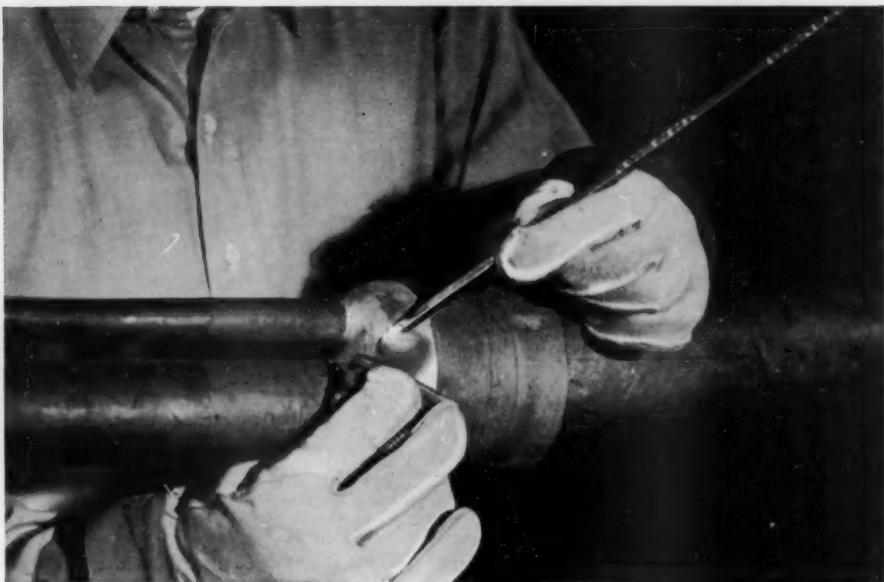
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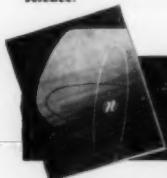
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# Use of Blood Groups in Human Classification<sup>1</sup>

William C. Boyd

Boston University School of Medicine, Boston, Massachusetts

Will he not fancy that the shadows which he formerly saw are truer than the objects which are now shown to him?

—PLATO, *The Republic*

**I**N RECENT YEARS there has been an increasing feeling, on the part of both geneticists and physical anthropologists, that genetical methods ought to be applied to the problems of the classification of man, and a number of proposals to this effect have been made. Nevertheless, new books of anthropology, as they have been published, have been found to contain much the same old classifications based on morphological characteristics, skin color, etc., even though the authors may have started with the announced intention of making use of the newer methods. It is clear that many a worker, attempting to apply genetical methods of taxonomy to man, has been disappointed, and, in fact, one scientist, formerly quite active in the field of physical anthropology, has now given it up, and announced in a letter to me: "I tried to see what blood groups would tell me about ancient man, and found the results very disappointing."

A careful analysis of the situation will show that such disappointment is based largely on two circumstances. First, there is the fact that the blood grouping genes affect invisible serological characteristics of the individual, and are thus never visible to the naked eye. It is to be feared that we are all too much inclined to be impressed by the visible as opposed to the invisible. Second, there is the fact that the layman's concept of race (which is that the human species can be divided up by valid, scientific methods, into various groups that are pretty different from each other and which will look pretty different from each

other) has been unconsciously retained by many scientific workers, and the hypothetical dissenting readers are unconsciously expecting that the new systems we propose to introduce will also provide us with startling differences in the appearance and behavior of the different "races" we define, and will feel let down to discover that the new classification does not, when all is said about it, reveal any very dramatic results.

If the blood grouping genes had affected, not characteristics of the blood, but prominent morphological or physical characteristics such as the shape of the head, color of the skin, etc., there cannot be the slightest question that they would already have been made the chief basis of a racial classification and would have been considered entirely adequate for that purpose.

## EQUIVALENCE OF GENES

From our knowledge of genetics we may see that there is nothing fundamentally different between the blood grouping genes as *genes*, and the genes which do affect morphological features. It is simply a historical accident that fairly adequate information was obtained about the mode of transmission of blood grouping genes before any information at all equivalent in amount or value was obtained about the genes affecting physical appearance.

In view of these facts, and since there seems to be no reason to suppose that the location of a gene in a chromosome, or the nature of the particular chromosome in which the gene resides, determines in advance the main or even the subsidiary characteristics which are to be influenced by the gene, it might be instructive to let our imaginations roam a bit. The outwardly observable effects of the blood group genes are, so far as we know, zero. Therefore let us make some arbitrary assumptions as to the sort of effect which the blood grouping genes could have produced, supposing them to have affected some of the external and visible char-

<sup>1</sup>This article is based on Chapter 9 of *Genetics and the Races of Man*, to be published October 4 by Little, Brown and Company. (Tables 1 and 2 appear in the book as Nos. 31 and 32.)

acteristics instead of serological characters, which are ordinarily tested for only in a laboratory. The insight we shall thus acquire will throw considerable light on the real nature of anthropological genetic classification and the sort of information which can be expected from it.

#### HYPOTHETICAL WORLDS

Let us suppose for the moment that the genes which at present operate to affect skin color and stature were to affect, instead, obscure serological properties of the blood or other relatively imperceptible physiological traits; and let us suppose that the present blood grouping genes affected, instead of the blood type, various morphological characteristics, easily distinguished by the casual observer. We now have considerable information about three series of serological allelomorphs. We can select three visible or measurable characteristics of the human being and suppose that each is affected by one of these series. It will probably be wise to oversimplify the picture considerably, and not try to take account of all the subtle serological differences and subgroups which can actually be identified within the blood grouping series of genes. It is clear, however, that if we were to take these into account we could, if we wished, considerably refine and complicate the picture which we are going to present now.

Since this situation is purely hypothetical we can make any assumptions we like and we shall probably do better to make some of the simpler ones. Let us suppose that individuals of the genetic constitution OO (which in actuality causes their blood to possess the properties which we know as group O) would possess a skin color about the Spanish, Italian, or Arab degree of pigmentation; and that those possessing the gene A were somewhat darker in appearance; and that those possessing gene B were a somewhat dark yellow, such as certain Mongoloids of today; and that those who possessed the genetic constitution AB were quite dark, but not actually "black" in color. Genotype AO would be a brown lighter than AA, and the genotype BO would be browner and less yellow than the genotype BB.

The way in which the A and B genes, when both present together in the genotype AB, would interact in producing skin color would, of course, really depend upon the exact mechanism of their action in the organism, the various enzyme systems which they controlled, etc.

#### POLYMORPHISM

One consequence of supposing the skin color was mainly determined by such a simple mechanism as this is, of course, that our various races would be polyphenic or "polymorphic" for skin color. This admis-

sion may at once cause some revulsion on the part of the reader who believes that all individuals of a given race should be alike in regard to the characters used in racial classification. Many examples of this tendency could be combed from the writings of early anthropologists, or from statements made by laymen today, but we may restrict ourselves to one. Franz Boas, in a book published in 1928, stated: "When we speak of racial characteristics we mean those traits that are determined by heredity in each race and in which all members of the race participate" (2). It is only fair to mention that Boas, one of our greatest anthropologists, later came to see the error inherent in this distinction of race. (In earlier pages of this book, we quoted the opinions of geneticists such as Dobzhansky that such a definition of race is impracticable.)

In reply to the objections raised by people who still take this old-fashioned point of view, we may point out that groups classified as "races" by physical anthropologists of the past, and even of the present day, are, in fact, often "polymorphic" for skin color. Examples are found in Russia and Arabia, China, etc. It is true that polymorphism may be the result of the mixture of racial groups of different degrees of pigmentation, as with American Negroes, and in hybrids in South Africa (9), but this is not always the case, and "pure" races are not always homogeneous for skin color. Polymorphism in regard to other characteristics is often found in ethnic groups regarded as homogeneous, but is hardly commented on. Eye color (blue, brown, gray, etc.) is an example; type of body build ("somatype") is another. In a number of racial groups several varieties of body build are found, as has been pointed out by Weidenreich (24). Stature also varies considerably, even in a relatively homogeneous group such as the Japanese (23).

If we were to suppose a somewhat different series of pigmentation effects to be produced by the blood group genes, and particularly if we were to suppose that gradations in skin color corresponding to the allelomorphic genes (O, A<sub>4</sub>, A<sub>3</sub>, A<sub>2</sub>, A<sub>1</sub>, B) determining the subgroups were produced, then the polymorphism which we should have to suppose as a result would be little, if any, greater than that which can actually be observed in many existing ethnic groups. So in all probability we may safely go ahead with our construction of hypothetical ethnic groups composed of individuals whose visible characteristics are determined chiefly by the blood group genes.

Let us further suppose specific hypothetical effects for the M and N genes. Let us imagine that the effect of the M gene was generally the production of a tall individual, whose stature, in the male, we may suppose would range from 168 to 172 centimeters or,

in other words, from about 5 feet, 6 inches, to about 5 feet, 7½ inches.

Let us suppose that the gene for N resulted in short individuals with a height, in the male, varying from 148 centimeters to 158 centimeters—in other words, about 4 feet, 10½ inches, to 5 feet, 2½ inches. Let us further suppose that the heterozygotes MN would be intermediate in stature. (We may recall that there is some evidence that, serologically, the heterozygote MN gives reactions intermediate in strength between the two homozygotes MM and NN.)

There are men in the world today taller than our hypothetical MM, and others shorter than our hypothetical NN, but the suggested range of height would, nevertheless, be impressive, if human psychology remained the same, for stature has always been considered a character of utmost importance. There can be few of my readers who have not experienced the emotion which results from looking up at a taller person, or looking down to a shorter person. Probably we could afford to let this case rest entirely on the testimony of tall female readers of this book who have found themselves, at parties and other gatherings, obliged to dance with men shorter than themselves. Eisenhower (7) recorded the indignation of Marshal Zhukov over the reports that he was shorter than his wife.

We shall here assume that there would be no sex differences in stature in our imaginary people, for, although sex is known to affect the expression in the individual of a number of autosomal genes (4), it does not affect blood group genes.

Passing to the Rh series of genes, we shall restrict ourselves, since the actual situation is rather complex, to supposing that the Rh negative gene would in this case act as a dominant, producing an eye structure similar to what is called the Mongolian (or epicanthic) eye fold. Individuals homozygous for the Rh positive gene would have European-type eyes.

#### IMAGINARY RACES

Remembering that these various assumptions are purely imaginary, let us consider what sort of race classification would have grown up as travelers from "civilized" countries gradually explored the rest of the world and finally tried to summarize and systematize their observations.

There can be hardly any doubt that the situation would have been considered very striking and, from the point of view of physical anthropologists who were writing fifty years ago, very satisfactory. In western Europe people varying in skin color from brown to dark-brown would predominate. (The darker brown would be uncommon.) In Asia and related

regions individuals of a rather dark-yellow color would be the common type, with a certain mixture of brown and dark brown. The frequency of very dark individuals would be at its height somewhere in central Asia. There would be good evidence that the yellow skin color found occasionally in Europeans had been brought by direct migration from Asia. There would be a fairly high incidence of very dark brown individuals in certain parts of Africa.

The lightest colored skins would be found in the various races of western Europe and certain parts of central Europe, in the East Indies, in the Australian aborigines, and in certain tribes of North American and South American Indians.

All the Indian tribes of both of the Americas would agree in being considerably taller than the average for the rest of the world, whereas the aboriginal inhabitants of Australia would agree in being distinctly shorter than the average. These differences would probably be considered very marked. (Serological characters of the blood, if differences were eventually discovered, would probably be found to vary so much with climate and environment that they would probably be considered useless for purposes of racial classification.)

One of the most notable observations would be that only in Europe and in the white inhabitants of America who are of European stock would the Mongoloid eye fold be observed to any extent. It would, therefore, be considered quite proper to mark off the European race as being absolutely distinct from all the other races of the world because of this striking morphological characteristic. The Basques would have a higher incidence of the eye fold than any other known people.

It would be observed that in the various great "racial" groups the skin color was not absolutely uniform. Nor would stature be found to be absolutely uniform within the groups in different parts of the world. In Asia and Europe, for instance, we should find that the majority of the inhabitants were of medium height, but that a certain number, of the order of 25 percent of the total, would be rather tall, and a certain number, also about 25 percent, would be rather short. "Clines" in stature would be found in Australia and up through the Pacific islands. Also, when the laws of heredity of these characteristics were investigated, it would be found that two individuals of medium height did not necessarily produce children who all grew up to a similar height. Instead, it would be possible for them to produce tall or short children, in addition to children of medium stature. This situation might be considered somewhat perplexing, but could easily be explained once the hereditary mechanism of the characteristic had been ascertained.

It would also be found that light-brown individuals

might result from a mating of dark-brown parents. The genetic analysis would not prove too difficult to carry out (contrary to the situation which actually prevails in regard to skin color in the world today).

In the actual world we know, the skin color of individuals is influenced—at least temporarily—by exposure to the sun, and this, in turn, may be related to their occupation. Also, there can be hardly any doubt that stature is importantly influenced by diet. We should therefore remind ourselves that in our hypothetical world, where we have given the serological genes the role of affecting skin color and stature, the climate, environment, occupation, and diet might also exert their influence and thus possibly complicate the genetic analysis. Let us oversimplify once more and suppose that this did not happen.

#### HYPOTHETICAL CLASSIFICATIONS

Given the hypothetical situation which we have just outlined, it may hardly be doubted that physical anthropologists would not have hesitated to classify mankind more or less as follows: (1) The European race, characterized by relatively light color and the presence of the Mongolian eye fold; (2) the Asiatic race, characterized by the predominance of yellow individuals, not having the epicanthic fold, but of about the same average stature as the European race; (3) the primitive American race, characterized in general by tall stature, no epicanthic fold, but varying from tribe to tribe in its skin color, which would range from brown to light-brown; (4) the aboriginal Australian race, a relatively light-colored people, but practically pygmies in stature, with no epicanthic fold; and (5) an African race, possibly characteristic of the equatorial regions of Africa, dark but with somewhat lighter skin than typical Asiatics, and having the epicanthic fold to a less extent than Europeans.

The European and Asiatic races would be imperfectly separated, but would be connected by a series of clines or intermediates in central Europe and Russia. This would be easily explained, however, as the result of repeated Asiatic invasions and migrations which had taken place in prehistoric and early historic times. The light color of certain individuals in southeastern Africa would be somewhat more difficult to explain, but the answer to all these questions might depend a good deal on the region in which anthropologists in our hypothetical world supposed mankind to have originated.

Two other questions would come up which would be not quite so easy to answer as the above: (a) why the aborigines of the American continent should be so tall, and (b) why the Australian aborigines should be so short. Archaeological evidence would indicate that

the people who migrated to America came across the Bering Strait region and were, on the whole, of medium height. In the early days of physical anthropology, in our hypothetical world, a good deal of loose speculation as to the effect of climate on stature would have been indulged in. As the science of anthropology advanced further, however, such explanations would be frowned upon, for the anthropologists would begin to insist that the only valid characters for racial classification are those which are nonadaptive and which are not affected by the environment. Investigations designed to test this point would probably not be found to detect any selective advantage or disadvantage characterizing either the A, B, M, or N genes.

The possession of the Mongolian eye fold by the Europeans and their North American descendants would be somewhat of a puzzle also. One would be obliged to suppose that it was the result either of mutations or of early mixtures of the European groups with some early *nonsapiens* or *sapiens* type of man.

The hypothetical distribution of morphological characteristics which would result from the imaginary effects of the blood grouping genes, which we have made up pretty much at random, would give each continent, on the whole, a clear-cut characteristic racial picture. Intergradations would be relatively infrequent, and it would be fairly easy to classify by inspection groups of individuals as coming from Europe, Asia, Africa, or Australia.

#### BACK TO REALITY

The foregoing paragraphs are not meant to be a jest, but are intended to illuminate the contrast in our attitude toward visible, physical characteristics such as skin color and stature and our attitude toward the invisible serological characteristics of the blood. If the blood grouping genes known at present really had the effects we have imagined, and if it were known how they were inherited, they would undoubtedly be considered highly satisfactory for racial classification. The average person is so impressed with skin color that he would doubtless be entirely satisfied of the importance of the pigmentation distinctions created by the A, B, O series of genes; and the hypothetical effect of the M and N genes on stature would be considered proof that these genes were of great importance in racial classification since they affected the characteristics of the skeleton.

We now leave the dream world we have just created, and try to face the apparently less exciting facts of the real world. There is no evidence that skeletal characteristics are more stable, in an evolutionary sense, than other inherited characters. The blood group genes do not affect, so far as we know, the skin

color, or the stature, or structure of the eye fold. Instead, they control the production of certain chemical substances in the blood. Since we have seen, however, that in fundamental importance to the organism, probably all genes are nearly equivalent, there is no reason why the blood group genes should not be just as important for purposes of racial classification as if they had in reality the hypothetical effects we have ascribed to them above. It is, in fact, rather puzzling that blood group genes have not been more often used for classification.

#### WHY WERE GENES NEGLECTED

The genes which could be most useful to us in anthropology are, in the present state of our knowledge, the blood group genes. But they have not been used much by the average physical anthropologist in recent years. There are a number of reasons for this.

(1) Physical anthropologists have preferred when possible to deal with skeletal material. This preference is partly due to the pious hope that characters of the skeleton, since it represents the harder and more permanent part of the human frame, will, therefore, on the whole be more permanent and less subject to modification in the course of evolution (16). There is no reason for believing that this actually is the case, however, and, actually, many of the mutations observed to occur frequently in *Drosophila* affect the skeleton, which in this species is on the outside. The chief reason for depending upon skeletons, of course, is their relative availability, especially for the study of ancient man. Although it has been possible to discover the blood groups of people who lived as long as 5,000 years ago (5), we cannot expect to push such investigation much farther back than this, and as to the color of the skin, the artistic ability, the musical sense of early man, or his capacity for adapting to a social group, we shall always be pretty much in the dark.

Most of the material available for the study of early man is skeletal, and a scientific study of this material certainly has its value. It is not the place of genetics to discourage the exploration of another field of science, but rather to offer checks on the hypotheses and assumptions which are used to examine and order that material. Most of the tie-up between archaeology and physical anthropology depends on the skeleton, and this is an important tie-up. Genetics can never replace the study of fossil remains, from the morphological standpoint in human or other paleontology. But it can do much toward the proper conceptualization of that study (26).

The geneticists have long realized the advantage of a classification based on known genes, and Dobzhansky (6), one of our leading workers in the field of

genetics, has stated clearly his own opinion that the study of geographic variation of a single human gene series, such as that which determines the blood groups, is capable of giving more information about the nature of races than could decades of mensuration and computing of racial averages. He does not deny, however, that the methods used by anthropologists in the past have some usefulness; he only insists that the limitations to these methods be understood.

(2) The second reason for the lack of interest in blood groups for classification was that the genetic variation from race to race was discovered only after other methods of anthropological classification had already been introduced and had enjoyed extensive use. Scientists, like other people, are conservative. (3) Many physical anthropologists, even today, do not understand the science of genetics well enough to appreciate the advantages which characteristics such as blood groups offer, and so have preferred to base their classification on traditional measurements, and on statistical averages determined from these. (4) A fourth reason was that the first advocates of blood group studies (18, 27), in their enthusiasm, claimed too much for their methods, and the physical anthropologists of today are still somewhat influenced by the reaction which resulted from the inevitable disappointment. (5) The fifth and perhaps most important reason is that the study of blood group frequencies very often does not confirm ideas about race which have already been developed on the basis of metrical and other observations, and the resulting classifications in many cases cut entirely across the traditional categories. Classifications according to blood group frequency can be entirely independent from that which results from classification based on the cephalic index or on skin pigmentation. (6) It is unfortunately true that one of the pioneers of the use of blood groups in anthropological classification (12) was partly responsible for diminishing the confidence in the method by

proposing a "biochemical index,"  $I = \frac{A + AB}{B + AB}$ , for use in racial classification. It was early pointed out that this index, since it took no account of the amount of group O in a population, could not tell the whole story, but in spite of this it is still sometimes referred to. Its use restricted still further the information which serology could offer anthropologists, and this was already rather limited (see below).

An increasing knowledge of human genetics offers us a new method of classification which may be of more fundamental importance than the old one, and we cannot, just because its implications are startling, reject it. We must ascertain what the facts are, define physical races as the gene frequencies show them

to be, or, if the data force us to such a conclusion, declare that the term "race" has no physical meaning.

#### RACIAL CLASSIFICATION BY BLOOD GROUPS

Ottenberg (18) attempted one of the earliest racial classifications based on blood groups. There were available at that time data on only one set of genes, the O, A, B blood groups, and consequently the result was not an adequate classification of races by modern standards (one criterion is not enough). Ottenberg's races were six: European; Intermediate—Arabs, Turks, Russians, etc.; Hunan—Japanese, South Chinese, Hungarians, Roumanian Jews; Hindu-Manchu—Koreans, North Chinese, Gipsies, Hindus; Afro-South Asiatic—Negroes, Madagascans, Malayans; Pacifico-American Indian—Indians, Australians, Filipinos, Icelanders. Snyder (27) made the Australians a separate race from the Pacific race.

It will be apparent to any student of anthropology that this classification makes some very strange bedfellows. Ethnic groups which can be related only in the remote way we are all related to each other are included in the same "race." It is not surprising that anthropologists took one look at this list, shuddered, and said, in effect, "No thanks; I'll take vanilla."

Maps of gene frequencies show that the O, A, B frequencies can be nearly the same in different parts of the world, in ethnic groups which can be only distantly related. As examples, we may consider the data shown in Table 1 (21).

TABLE 1  
SIMILAR BLOOD GROUP DISTRIBUTIONS IN DIFFERENT PEOPLES

People	Place	Percentage of groups			Frequency of gene		
		O	A	B	AB	p	q
Eskimo	Labrador and Baffin Island	46.5	53.5	0	0	.318	0
Aborigines	W. Australia	48.1	51.9	0	0	.306	0
Chinese	Canton	45.9	22.8	25.2	6.1	.154	.168
Katangans	S. Belgian Congo	45.6	22.2	24.2	8.0	.156	.169
Russians	Kazan	41.9	27.3	23.3	7.5	.194	.169
							.648

A more recent attempt to use serological characters in anthropology is found in a book by Lahovary (14). This author makes some use of the M and N genes, and occasionally other blood factors, in addition to the classical O, A, B groups, and he distinguishes the following races: (1) European (Nordics and Alpines of Europe and the Near East); (2) Mediterranean; (3) Mongolian (Central Asia and Eurasia); (4) African (Blacks); (5) Indonesian; (6) American Indian; (7) Oceanic, including the Japanese; (8) Australian (a subvariety of the Oceanic).

Lahovary was aware that a racial classification based merely on the O, A, B groups would in many cases give results which would not fit well with older ideas about race. He did not wish to abandon the older points of view, however, so he attempted a compromise. In some cases he made use of information about the M, N types, and occasionally other blood factors, to help separate populations not clearly distinguished by A and B. In other cases, where populations probably not closely related proved to have about the same frequencies for A and B, he postulated that the A or B in one of these populations was "of different intensity." It is not too clear what this means, and it is not true that the A or B antigens differ in any detectable way from population to population (except for the different proportions of the subgroups,  $A_1$  and  $A_2$  of the A antigen). The idea probably goes back to the speculations of Hirschfeld (11) about an "evolution" of the A and B antigens from O, and this, in turn, is largely based on the old idea, now disproved, that American Indians belong only to group O.

The classifications of Lahovary do not violate ordinary anthropological notions so much as those of Ottenberg, but at the same time it must be admitted that Ottenberg, somewhat like Dixon in the metrical field, showed more courage in following his premises to their inevitable conclusions. Lahovary hedges at numerous points.

Most of Lahovary's book is restricted to a consideration of the races of Europe, where there are found, it is true, certain well-marked gradients or clines in the gene frequencies of A and B. This enabled him to make subdivisions at practically any point, and thus devise "serological races" which did not agree too badly with European races as defined on morphological, pigmentation, and linguistic grounds. But a classification based on the B gene, for instance, will never agree well with one based on the cranial index or on skin color. In other words, Lahovary failed to realize that the characters by which we define races are independent of each other, and we must not expect a classification by one character to agree with another very closely, even in Europe, where the present populations are to a large extent traceable back to a few sources, and even these could not have been too different. It does not seem, therefore, that Lahovary has made a very great advance in methods of classifying races, in spite of his espousal of the genetic method, which, in his case, amounts mainly to the use of the classical A, B, O blood groups.

We have already implied that a valid and sensible classification of human races, based on genetic data, is possible. Suppose we show the same audacity as Ottenberg, but make use of the great amount of data

which has accumulated since. What sort of racial categories shall we be led to create, and will they be utterly different from the older ideas which were based on morphology and physical appearance?

Wiener (28) has proposed the following racial classification, based largely on the O, A, B, and the Rh factors:

*Caucasoid group*—highest incidence of the Rh negative gene, relatively high incidence of genes for  $Rh_1$  and  $A_2$ , moderate frequencies of other blood group genes.

*Negroid group*—highest incidence of gene  $Rh^s$ , moderate frequency of the Rh negative gene, high relative incidence of genes  $A_2$  and the rare intermediate  $A$  and  $Rh$  genes.

*Mongoloid group*—virtual absence of Rh negative gene and gene  $A_2$ , highest incidence of the rare gene  $Rh^z$ .

Wiener's classification, as first enunciated, distinguished only three races, and it seems likely from past experience that we shall find it convenient to divide the human species into rather more than three races (recall that the number of races to be recognized in a species may be to a large extent arbitrary). However, it must be admitted that this classification makes much more "sense" than those just referred to. But by making more use of M, N data, we can improve it still further. Wiener, in fact, attempted this (30) and as a result subdivided his Mongoloid group into an Asiatic subgroup, a Pacific Island and Australian group, and a group including the American Indians and Eskimos.

From what has been said already, and particularly from our hypothetical example in which we allowed certain blood grouping genes to be supposed to have effects on morphological and other physical characteristics of man, it is obvious that we could, if we liked, find ample justification for classifying men into a larger number of different races on the basis of blood groups. The races which would result from such a classification, however, would coincide only in part with the races of man as they have previously been delineated by anthropologists, and in some cases would appear even to be inconsistent with the known history of the people. The American Indian, for instance, known to be derived by direct descent largely, or at least partly, from Mongoloid ancestors emigrating from the Asiatic mainland, would have to be placed in a quite different race on the basis of blood groups. This only serves to emphasize the meaning which is being given the term "race" in this book. Serological factors are almost the only human characteristics of which we know the exact mechanism of inheritance,

and it has been shown here that only the use of characters inherited in a known manner will satisfy our criteria for a satisfactory classification of races. The very idea of racial differentiation implies that geographically isolated groups, although ultimately of the same origin, may eventually come to differ, and we have explained the mechanisms by which such differentiation can be brought about. Therefore, there is no reason why the Mongoloid appearance of many American Indians should in itself prevent our placing them in a racial category different from that of contemporary Asiatics. Aside from blood groups, we do not know what proportion of Mongoloid genes they really have, for we have not solved the problem of how many genes cooperate to produce the "Mongoloid" appearance.

#### THE RACES DEFINED HERE

I have previously suggested (3) the following tentative racial classification based on gene frequencies. It differs only slightly from Wiener's.

1. Early European group (hypothetical)—possessing the highest incidence (over 30 percent) of the Rh negative type (17) (gene frequency of  $rh > 0.6$ ) and probably no group B. A relatively high incidence of the gene  $Rh_1$  and  $A_2$ . Gene N possibly somewhat higher than in present-day Europeans. Represented today by their modern descendants, the Basques.

2. European (Caucasoid) group—possessing the next highest incidence of  $rh$  (the Rh negative gene) (see Table 2), and relatively high incidence of the genes  $Rh_1$  and  $A_2$ , with moderate frequencies of other blood group genes. "Normal" frequencies of M and N, i.e., M = ca. 30 percent, MN = ca. 49 percent, N = ca. 21 percent. (The symbols in italics stand for the genes, as opposed to the groups.)

3. African (Negroid) group—possessing a tremendously high incidence of the gene  $Rh^s$ , a moderate frequency of  $rh$ , relatively high incidence of genes  $A_2$  and the rare intermediate (29)  $A$  ( $A_{1,2}$ , etc.) and  $Rh$  genes, rather high incidence of gene B. Probably normal M and N.

4. Asiatic (Mongoloid) group—possessing high frequencies of genes  $A_1$  and  $B$ , and the highest known incidence of the rare gene  $Rh^z$ , but little if any of the genes  $A_2$  and  $rh$  (the Rh negative gene). Normal M and N. (It is possible that the inhabitants of India will prove to belong to an Asiatic subrace, or even a separate race, serologically, but information is still sadly lacking.)

5. American Indian group—possessing varying (sometimes high, sometimes zero) incidence of gene

TABLE 2  
APPROXIMATE GENE FREQUENCIES IN THE SIX GENETICALLY DEFINED RACES

Gene	1 Early European	2 European (Caucasian)	3 African (Negroid)	4 Asiatic (Mongoloid)	5 American	6 Australian
A (p)						
( $A_2 + A_1$ ) Ratio	ca.0.25	0.2-0.3	0.1-0.2	0.15-0.4	0-0.6	0.1-0.6
$A_2/A_1^*$	> 0.5?	0.1-0.3	ca.0.4	0	0	0
B (q)	< 0.01?	0.05-0.20	0.05-0.25	0.1-0.3	0	0
N n	> 0.5?	0.3-0.5	ca.0.5	0.4-0.5	0.1-0.2	0.8-1.0
Rh neg. (r)	> 0.5?	0.4	ca.0.25	0	0	0
Rh <sup>e</sup> (R <sup>e</sup> )	< 0.1?	ca.0.1	ca.0.6	ca.0.1	ca.0.01	ca.0.01
PTC†	ca.0.5	0.55-0.7	ca.0.45	0	0	0
Nonsecreting‡	?	ca.0.5	> 0.6	0?	0?	0?
Other genes§	?	rh'	$A_1, \pm$	Rh <sup>a</sup>	Rh <sup>a</sup>	Rh <sup>a</sup>

\* For convenience in calculation, the ratio of the two subgroups,  $A_2$  and  $A_1$ , and not the ratio of the gene frequencies,  $p_2/p_1$ , is given.

† The recessive gene for *not* tasting phenyl-thio-carbamide.

‡ The recessive gene for *not* secreting water-soluble blood group substances into the gastric juice, saliva, etc.

§ Other genes the frequency of which seems to be higher in this population than in other races.

$A_1$ , no  $A_2$ , and probably no  $B$  or  $rh$ . Low incidence of gene  $N$ .

6. Australoid group—possessing high incidence of gene  $A_1$ , no  $A_2$ , no  $rh$ , high incidence of gene  $N$  (and consequently a low incidence of gene  $M$ ). Possessing  $Rh^e$ .

Table 2 shows world distribution of these races.

Such a classification corresponds well, omitting the inevitable intermediates, *with geography*.

In addition to the blood group genes, the frequencies of two other genes, neither strictly serological, help us in making our new racial distinctions. These are the genes for tasting PTC and related compounds (19), and the "secreting gene" (20, 22). The information we possess about the world distribution of these genes is not very great, but it will be seen that some, at least, of our new races differ in respect to the incidence of these genes. Further study should add many such new genes to our list, and enable us to subdivide our present races. We do not propose to make a racial analysis of all the various populations of the world at the present time, however, but, having indicated the general method, leave the more detailed application of it to future students, who will find more adequate and more precise data at their disposal.

#### GENERAL CONSIDERATIONS

Our six genetically determined races certainly conform in a broad way to geography. Striking differences in certain gene frequencies mark off the inhabitants of the various continents. This is not surprising, since the evolutionary mechanisms which can produce racial differentiation are unlikely to do so unless we have at least a certain degree of geographic isolation. Genetic interchange between the inhabi-

ants of the different continents was probably, during the days of prehistory, relatively minor.

It must not be thought that the divisions between our genetic races will be absolutely sharp, any more than is the difference between races which are characterized by any other method. Isolation has not been absolute enough for that. Also, we must recall that, although isolated groups originally alike may diverge from each other in regard to a number of characteristics, there is no law which says that they *must* diverge, especially in regard to characters having only slight adaptive value. In any case, migration and mixture have been going on, at a greater or less rate, throughout most of human history.

To consider some special difficulties, it will be noted that our scheme of six genetic races makes no provision for a Pacific race, unlike some of the earlier schemes. The reason for this is that the Pacific peoples do not agree in exhibiting any distinctive combination of frequencies of the genes which we have thus far identified. The aborigines of certain islands near Australia show  $M$  and  $N$  frequencies similar to the Australians and are thus intermediate in this respect. However, they mostly have considerable amounts of the gene  $B$ , and we have seen that this is not a characteristic of the Australians. Also, the  $M$  frequencies of the Pacific peoples gradually rise to the European-Asiatic norm as we travel northward and westward. These Pacific peoples do not have gene frequencies constant enough for us to lump them with either the Australians or the Asiatics, or to define them as a separate race.

As we travel toward the Americas, we find the  $M$  frequency begins to rise, and the frequency of  $B$  drops off rapidly to zero, thus giving us populations (25) which are intermediate between the Asiatics and the

American Indians. Nevertheless, there is no special reason to suppose that this is due to the introduction of any Polynesian blood into America, and/or American Indian blood into Polynesia.

Similarly, we shall have a very hard time deciding just where the boundary is to be drawn between European and Asiatic, unless subsequent study reveals some sharp discontinuity in the frequency of the Rh negative gene, perhaps somewhere between the former German-Polish border and central Siberia. But gene interchange has been so easy on the great Euro-Asiatic continent that we can hardly expect to find a sharp racial boundary.

On the other hand, if we examine populations in regions where the geography has enforced rather complete isolation, we often find, as we might expect, that they differ sharply from the inhabitants of neighboring continents. Thus the natives of the Aleutian Islands (15), although they, like other American aborigines, are mongoloid in appearance, differ just as sharply as do the other Americans from any Asiatics yet tested, by having characteristically low frequencies of N (Table 2). And the Greenland Eskimo, although not too far from Europe, and exposed for centuries to European influence, also prove to be characteristically American in regard to their lack of B, high frequency of A, and low N (8).

Data are insufficient for discussion of other transitional peoples, such as the inhabitants of North Africa, but it can hardly be doubted that many examples of intermediate races will be found. We should do well to consider that there may never have been any pure races, before we call such peoples "mixed races."

#### SIMILARITY TO OLDER CLASSIFICATIONS

It will be noted that our proposed racial classification, although it is based upon gene frequencies, as we decided a valid classification must be, does not really differ in any very startling way, insofar as the ultimate categories are concerned, from some of the older classifications based on skin color, hair form, etc. Far from discouraging us, this should be a sign that our new methods are not doing so badly. For, in spite of all protestations that they were considering race and not geography, most writers on anthropology have generally tried to set up classifications that made sense geographically. For this reason, they emphasized—often in the course of a single work—various things at various times: sometimes skin color, sometimes head form, sometimes something else. Consequently they always reached, except when some bold worker like Dixon took the bit in his teeth and ran past all warning signals, a final goal of human races distributed roughly according to geography and common descent. All we have done is to show that the same thing can be

accomplished more simply, and without so many inconsistencies in the application of our method, by considering gene frequencies.

#### ADVANTAGES OF THE GENE METHOD

But it must not be thought that the use of the genetic method has merely served to confirm what was already known. This method has advantages which we have already pointed out and which we may go over briefly again.

(1) The method of gene frequencies is completely objective (subject to the qualification that our decision as to what boundary between frequencies is to separate two races remains always a man-made and arbitrary decision); (2) the gene method is quantitative rather than qualitative, so the observed frequencies give us some idea of how much different races differ from each other, and the consequences of race mixture can be accurately predicted.

As an example of point (2), we may mention the Australian aborigines and the Ainu. Both these peoples have been called by some authors "basic white" (1, 13). However, in the present state of our knowledge of the inheritance of skin color, we cannot state how much the very dark skin of the Australian marks him off from the European. But a glance at his blood group frequencies tells us at once that he is pretty similar in regard to the original absence of B, but different in regard to M and Rh negative. We can probably account for the acquisition of the Rh negative gene by the Europeans by the hypothesis of mixture, and the peculiar M frequencies of the Australian by random genetic drift. Thus it is not impossible to see a common origin for these diverse peoples, although they have by this time differentiated into separate races.

In regard to the Ainu, we find a frequency of B which suggests considerable Mongoloid mixture, but the M frequency is closer to that of Europeans. Random genetic drift has apparently not affected the M of the Ainu much. The B observed (ca. 30-40 percent) is, however, so tremendously high that we cannot consider the Ainu, in spite of his light skin color, to be as closely related to Europeans as are the Australian aborigines (unless, of course, we consider it probable that random genetic drift or repeated mutation has raised the B frequency). It seems more plausible to suppose that the darker skin of the Australian has been acquired since his arrival in Australia, probably by the action of natural selection.

#### RACIAL SUPERIORITY

The genetic classification of races is more objective, and better founded scientifically, than older classifications. The differences we find between races are in-

herited in a known manner, not influenced by environment, and are thus pretty fundamental. But the new criteria differ from some older criteria in an important respect. In certain parts of the world, an individual will be considered "inferior" if he has, for instance, a dark skin, but in no part of the world does the possession of a blood group A gene, or even an Rh negative gene, exclude him from the best society. There are no prejudices against genes. And since we have absolutely no reason to think that the possession or lack of any of the genes we have considered here confers on its possessor any advantage as a potential

contributor to the advance of cultures and civilizations, there is no reason that any prejudice should exist. We have already pointed out that there are actually no grounds, other than prejudices and emotions, for objecting to a dark skin, but it is not very easy to convince certain individuals of this (10).

So, although we have found a method of race classification which gives promising results, we have found no indication of the existence of any inherited racial superiority or inferiority. In the present state of confusion about racial issues, this is a point which deserves to be underlined.

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# Technical Papers

## Nitrogen Fixation by the Green and Purple Sulfur Bacteria<sup>1</sup>

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The relationship between hydrogenase, the enzyme specifically activating molecular hydrogen, and the nitrogen-fixing system in *Azotobacter* was established by Lee and Wilson in 1943 (3). This suggested that an organism that possesses hydrogenase may be a potential nitrogen-fixer. At that time representative genera of heterotrophic bacteria were tested using the sensitive isotopic technique, but the results were negative. Recently interest in this relationship has been renewed through the demonstration by Gest and Kamen (1) that photoproduction of H<sub>2</sub> by *Rhodospirillum rubrum*, a photosynthetic non-sulfur bacterium, was inhibited by molecular N<sub>2</sub>. This unexpected analogue of the inhibition of nitrogen fixation in *Azotobacter* by H<sub>2</sub> (5) suggested that *Rhodospirillum* might fix nitrogen, a suggestion that was readily confirmed (2, 4). Because of the importance of this discovery for a knowledge of the mechanism of biological nitrogen fixation, as well as its significance for the biogeochemistry of nitrogen, tests of other organisms known to contain hydrogenase are desirable. Of the untested hydrogenase-containing organisms (4), the purple sulfur and the green sulfur photosynthetic bacteria appeared to be the most likely candidates for hitherto unsuspected nitrogen-fixing ability. Through the courtesy of Mr. Helge Larsen and Professor C. B. van Niel, who kindly supplied us with representative cultures, we have recently examined this possibility.

The cultures tested were from two photosynthetic families: *Chromatium* sp., an uncharacterized species, isolated from marine mud, represented the purple sulfur bacteria; and *Chlorobacterium* sp., an organism known to carry out the reaction, 2 H<sub>2</sub> + CO<sub>2</sub> → (CH<sub>2</sub>O) + H<sub>2</sub>O, represented the green sulfur bacteria. If a heavy inoculum of either of these organisms was added to a nitrogen-free medium containing minerals, bicarbonate, and a suitable hydrogen donor, profuse growth took place when the culture was incubated in the light under molecular nitrogen.

The inoculum for either culture was grown in a mineral medium containing NH<sub>4</sub>Cl 1.0 g, KH<sub>2</sub>PO<sub>4</sub> 1.0 g, MgCl<sub>2</sub> · 5H<sub>2</sub>O 0.2 g, NaCl 10.0 g, NaHCO<sub>3</sub> 2.0 g, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> 1.3 g, Na<sub>2</sub>S · 9H<sub>2</sub>O 0.05 g, FeCl<sub>2</sub> · 6H<sub>2</sub>O 0.5 mg, tap water 1 liter. The pH was adjusted to 7.4 for *Chlorobacterium* and to 8.5 for *Chromatium*. The level of NaCl was increased to 3% for *Chromatium*, and dl-malic acid was

added to the medium to increase the speed of growth. An unwashed inoculum of 1.5 ml of a 4-day culture was added to 40 ml of a similar medium, except that it contained no added nitrogen. Nitrogen added in the inoculum and the tap water brought the initial concentration to about 15 µg N per ml. The cultures were incubated in artificial light under 0.8 atm of N<sub>2</sub>. Controls analyzed at zero time were included, as well as controls that were incubated under H<sub>2</sub> rather than N<sub>2</sub>. At the end of the incubation period, the nitrogen content was determined by a standard semimicro Kjeldahl method. Essentially the same general procedure was followed in the isotopic trials. The results are given in Table 1.

TABLE I  
NITROGEN FIXATION BY PHOTOSYNTHETIC BACTERIA

Experiment	Time, days	Total N in µg/ml		
		Control	Under H <sub>2</sub>	Under N <sub>2</sub>
<i>Chlorobacterium</i>				
1	4	14, 14	17, 19, 22	30, 33, 32
2	3	12	14	23
	4	..	12	30
	5	12	14	32
3	5	14	14	24, 24, 31
	9	..	..	40, 36
<i>Chromatium</i>				
4	5	10, 11, 11	11, 16	47, 56
	11	9	14, 14	59, 57
5	3	12	..	24
	4	..	15	32
	5	12	12	43
6	4	15, 16	..	37, 40

The final total nitrogen found in cultures of *Chlorobacterium* was about 35–40 µg/ml, independent of the initial nitrogen content or time of incubation. This limit was probably imposed by changes in the medium accompanying the photosynthetic reaction. Fixation by *Chromatium* showed no such definite restriction; if incubated for 2–3 weeks, fixation of 75–100 µg N/ml could be obtained. The results of the Kjeldahl trials were confirmed by the isotopic technique. When supplied an atmosphere containing 1.65 atom % excess of N<sub>2</sub><sup>15</sup> *Chromatium* accumulated 0.442 atom % excess of N<sup>15</sup> in one second and 0.298% in a second. The corresponding figures for *Chlorobacterium* were 0.318% and 0.203%. Controls in N<sub>2</sub><sup>14</sup> showed no change beyond the error of the experiment (about ± 0.03 atom %).

From the evidence in this and previous papers (2, 4), it seems that the ability to fix atmospheric nitrogen is widespread among the photosynthetic bacteria, positive findings having been established for representatives of the three families *Athiorhodaceae*, *Thiorhodaceae*, and *Chlorobacteriaceae*. The discovery is noteworthy for several reasons, chief of which is that the initial test was

<sup>1</sup> Supported in part by grants from the Rockefeller Foundation and from the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

not an empirical choice but was suggested by a consideration of the specific function of H<sub>2</sub> in the mechanism of biological nitrogen fixation—certainly a significant example of the role of theory in research. Likewise worthy of mention is that these photosynthetic organisms are the first bacteria to be unequivocally established as nitrogen-fixers since the discovery of *Azotobacter*, and that they are the anaerobic analogue of the blue-green algae as *Clostridium* is to *Azotobacter*. One member, *Rhodospirillum*, also possesses the distinction of having its nitrogen-fixing ability first demonstrated by the use of an isotope, then confirmed with Kjeldahl analyses (2, 4), a reversal of the usual procedure, but one that seems appropriate for this atomic age.<sup>2</sup>

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<sup>2</sup> Since this manuscript was submitted, Duchow and Douglas (*J. Bact.*, 1949, **58**, 409) have described a new genus of photoheterotrophic bacteria, *Rhodomicrobium connelli*. Although related biochemically to the *Athiorhodaceae*, its unusual morphology and mode of cell division suggest that it should not be included among the *Eubacteriales*; pending further investigation they suggest it be placed in a provisional appendix to the *Schizomycetes*. Through the courtesy of Prof. Douglas we obtained a strain of this interesting organism for test of nitrogen fixation. Positive fixation has been obtained in both Kjeldahl and isotopic experiments.

## Windowless, Flow Type, Proportional Counter for Counting C<sup>14</sup><sup>1</sup>

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The need in this laboratory for better counting of BaCO<sub>3</sub> samples with low activity has led to the design, construction, and use of a flow type, windowless, proportional counter (1, 2, 4).

The advantages to be gained by using proportional counting rather than Geiger-Müller counting are: (1) a higher maximum counting speed and no dead time corrections; (2) less sensitivity of the counter to gas contamination; (3) indefinitely long counter life; and (4) the opportunity to use pulse discrimination to reduce the background.

Operation in the proportional region necessitates the use of an amplifier of voltage gain between 100 and 1,000. This places more stringent conditions on the in-

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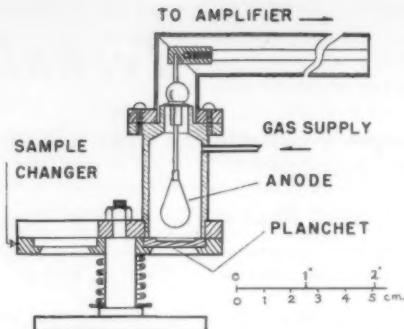


FIG. 1. Section of flow counter and sample changer.

sulation, shielding, and line isolation of the circuits than is the case with Geiger-Müller counting.

The entire counting apparatus consists of (1) the counter, (2) the sample changer, (3) the electronic unit, and (4) the gas supply tank and connections.

The gas used is argon plus 5% CO<sub>2</sub> and is purchased already mixed. The gas flow is controlled by a needle valve with an extended handle and two stops, one for the flush position and one for steady flow. From the valve the gas is piped to an oil bubbler and thence to the counter. The gas can escape around the planchet and through the hole below.

The electronic unit is a Model 162 amplifier-scaler made by Nuclear Instrument and Development Laboratories. The amplifier has a maximum gain of 400 and the scaler will pass .40-v pulses. The counter is coupled directly into the amplifier input by a short piece of coaxial line. With this arrangement no preamplifier is required and the interference picked up in connections is minimized. An isolation transformer in the 110-v supply is necessary to prevent line interference.

A section of the counter and the sample changer is shown in Fig. 1. The counter has a  $\frac{1}{4}$ -in. diam brass cathode and an anode consisting of a loop of .002-in.-diam tungsten wire. The loop is 9 mm by 17 mm and reaches to within 5 mm of the bottom of the planchet. The planchets used are of stainless steel and have a recess 9/16 in. in diam and .037 in. deep. Measurements of the asymmetry of sensitivity of this counter have been made. For a small spot source placed on a planchet near the edge of the recess, the rate of counting with the source in the plane of the loop is 10% more than at 90° from this position. For a reasonably uniform sample, therefore, the asymmetry is negligible.

The sample changer has a rotating disk as shown in Fig. 1, with two holes for planchets and a spring, not shown, which positions the planchets in the counter by catching in each of two notches in the rim of the disk.

Ten seconds has been found to be an adequate time for flushing the counter. If flushing is inadequate, the counting rate is depressed until the air has had a chance to clear out. Thus a method of checking on the presence

of air is necessary to see if further flushing increases the counting rate.

The counter is operated with the amplifier gain set at X1-30, so that only pulses larger than about 2 mv are registered on the scaler. Under these conditions the relative counting rate for a BaCO<sub>3</sub> sample as a function of voltage is indicated in Table 1. Although the plateau

TABLE I  
COUNTING DATA

Voltage	Relative rate, $R$	Background, $R^*$	$\frac{B}{R^2}$
1,500	0.64	0.9 cpm	2.2
1,600	1.00	2.3 cpm	2.3
1,700	1.06	4.8 cpm	3.9

\* Partial lead shielding.

slope is rather more than that for a good Geiger-Müller counter, the voltage regulation has been found to be quite good enough to give consistent readings of activity relative to a standard.

It will be noticed from Table 1 that the background is low but that it increases more rapidly with voltage than the BaCO<sub>3</sub> counting rate. This may be accounted for by the variability and average smallness of cosmic ray ionization. In any case, this change of background with voltage poses a question as to what operating voltage is best for weak-sample counting. It can be shown that the background ( $B$ ) divided by the counting rate ( $R$ ) squared is proportional to the time required to count a weak sample to a given accuracy. Of the voltages shown in Table 1, 1,600 v was chosen for operation of the counter, since this voltage is in the plateau range and gives a low value of  $B/R^2$ .

The same criterion may be applied to compare this flow counter with a standard type of end-window counter used in this laboratory. Taking values of 0.4 and 0.16 counts per disintegration for the over-all efficiencies and 3 cpm and 24 cpm for the backgrounds, the flow counter is seen to be 50 times as fast for weak samples. This is equivalent to saying that, for a given time and percent accuracy, the flow counter can count samples which are weaker by a factor of  $\sqrt{50} = 7.1$ .

A test for coincidence losses was made by following the decay of a sample of C<sup>14</sup>. The counting rate decayed from the initial rate of 86,000 cpm with a half-life of 21 min. The semilog plot of the data was straight within the counting errors, whereas if significant counting losses had occurred the data would have been below the line at the higher end. From the theory of proportional counter action one would expect the limitation on the maximum speed of counting to be imposed by the circuits of the register rather than by the counter itself.

Several measurements of self-absorption curves in the end-window and flow counters were made on the same sets of planchets. The samples were of different weights but of constant specific activity so that the counting rates would be expected to obey the equation,  $N = N_0 (1 - e^{-\mu m})$ . For both counters the experimental points above 3

mg/cm<sup>2</sup> were well fitted by this equation. The best values of  $\mu$  were found to be .31 cm<sup>2</sup>/mg for the flow counter and .30 cm<sup>2</sup>/mg for the end-window counter (2, 4). The ratio of counting rates was found to have a nearly constant value of about 2.6 except for samples of 3 mg/cm<sup>2</sup> or less. Between 3 mg/cm<sup>2</sup> and .5 mg/cm<sup>2</sup> the ratio increases from 2.6 to 3.1. This increase in the ratio for thin samples may be accounted for by soft back-scattered radiation which will penetrate neither the mica window nor the thicker layers of BaCO<sub>3</sub>.

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### Preliminary Report on a Device for the Objective Measurement of the Negative Afterimage Phenomenon

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The study of afterimages has received considerable attention by psychologists as well as physiologists for more than a century. Clinical application (2-4) of changes in the afterimage under pathological conditions has been attempted by several workers. A considerable difficulty in investigation of this phenomenon lies in the fact that until now the subject had to be trained for the observation of afterimages. Persistence, concentration, and a good measure of intelligence and reliability are required when reporting on the appearance, disappearance, and nature of afterimages produced after a subject has gazed fixedly for periods ranging from 5 to 30 sec at a brightly illuminated object.

An experiment first described by Bidwell (1) has been the basis for the development of an instrument which makes it possible to obtain reliable measurements of some aspects of the negative afterimage, under conditions that make it unnecessary to train the subject for his observations. Since only the afterimage and not the original stimulus is perceived with this method, there is no shift of gaze or attention, an end point can be determined on a measuring scale, and observation becomes so simple that even children and mentally disturbed patients may be studied without sacrificing too much of the reliability of the results.

If a disk, half white and half black, with a sector cut out as a window, is rotated at a certain speed in front of a brightly illuminated colored object in such a manner that first the object through the window, then the white part, and, finally, the black part of the disk are exposed

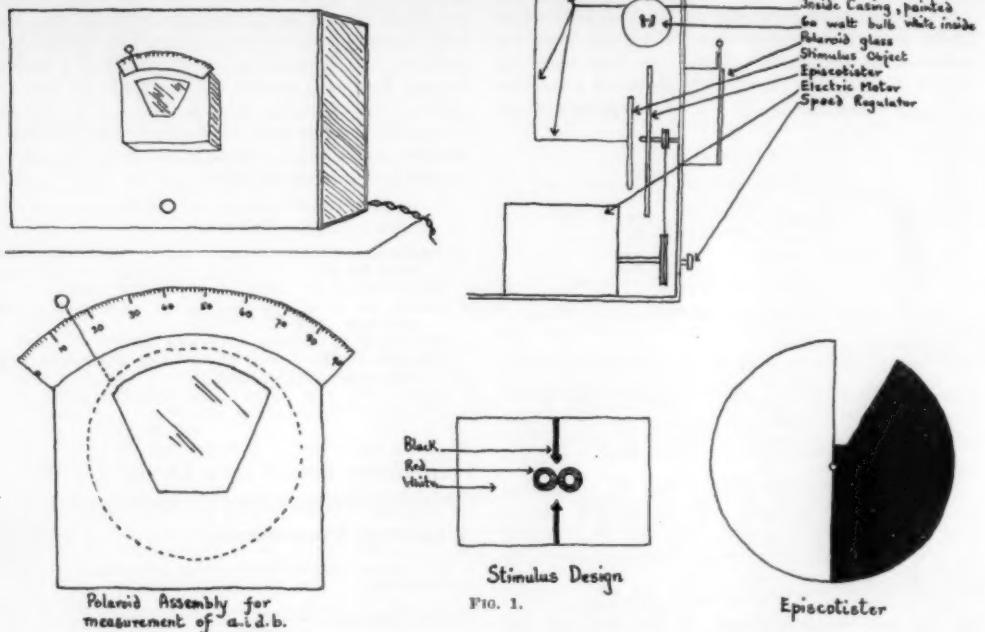


FIG. 1.

to the eye, a negative afterimage in complementary colors is projected onto the rotating disk. The significant difference in the refractory time of the unit of the retinocortical system responsible for the perception of the afterimage and the unit responsible for the reception and signal conduction of the original stimulus makes it possible to arrange conditions so that the original stimulus never reaches consciousness, although it is constantly operating to maintain the afterimage in the field of conscious perception. Thus, a red circle will appear green to the observer who is unable to see the original color at any time. The principal variables of this effect are the speed of rotation of the disk, and the brightness of illumination of stimulus object and disk. Brightness of illumination proved to be the more practical variable with regard to quantitative measurement. A certain minimum brightness is required for the production of an afterimage. This minimum brightness has a fairly constant value for the same individual under similar conditions. It can be measured easily, as the complementary color of the afterimage changes into the original color of the stimulus when this threshold value has been reached, by gradually dimming the light that reaches the eye from stimulus and disk. This value will be referred to as afterimage disappearance brightness (a.i.d.b.).

Various methods of regulating the brightness of stimulus and disk were tried. An optical method had to be employed, since regulation of the electrical power supply to the incandescent source of illumination influences the color of the light, and thus introduces another variable.

Control of brightness was finally achieved with two polaroid glass filters interposed between the rotating disk and the observer's eye. These filters make it possible to regulate the amount of light reaching the eye from the original stimulus, and to determine the threshold value necessary for the production of a negative afterimage. Since the appearance and duration of afterimages are functions of the factor of illumination, one measures the "susceptibility" to negative afterimages by dimming the light until either no afterimage is produced, or its duration is so brief that it does not persist long enough to prevent the perception of the original stimulus. The polaroid filters allow for a rotation of 90°, and the angle at which the last trace of the complementary color of the afterimage has disappeared and the stimulus object is perceived entirely in its original color, is determined on a scale. The dimming of the light may be done by the observer himself or by another person. Most other workers have dealt with the quantitative aspects of afterimage lag and afterimage duration. Our method is concerned with the measurement of the threshold value of the illumination necessary for the production of afterimages.

Since brightness of illumination serves as the measured variable, it is essential to keep all other factors constant. Speed of rotation of the episcotister is kept constant by adjusting it with friction brakes or a rheostat, until a stroboscopic disk mounted on the back of the episcotister shows that it turns at 5 rps.

Fig. 1 gives a schematic illustration of the apparatus. The insets show the episcotister, the polaroid eyepiece,

and the stimulus design we have been using. The source of illumination is a 60-w incandescent bulb, 5 in. above the center of the stimulus card and 5 in. above the center of the front of the episcotister. It is arranged so that it illuminates the stimulus object as well as the front of the episcotister. In another model it might be better to have independent sources of illumination for the stimulus object and the episcotister. It seems that a more intense complementary color is produced if the stimulus object receives more light than the episcotister, although the latter has to be strongly illuminated also. Lamp, stimulus object, and the upper part of the episcotister are encased in a metal box painted white, while the inside of the rest of the apparatus is painted black.

The episcotister is made of plywood or metal (diam 8.5 in.). Half of it is painted white; the other half of the episcotister is covered with black velvet (and of this part a sector of 30° is cut out to serve as a window, behind which the stimulus object is presented).

The stimulus object consists of a card 5 in. × 6 in. with the design as shown in the illustration. The arrows are black, the two circles bright red, the background white. Letters, numbers, or pictures may be used instead of the "abstract" design, but associations to meaningful stimuli would probably introduce into the set another psychological variable, mainly determined by neurophysiological factors. Red as a stimulus color produces the best after-image under the conditions of this experiment.

The polaroid assembly consists of two round polaroid glass filters of fairly neutral gray tint. They are mounted under a scale on which the angle of rotation of the filter is read.

The subject is instructed to look with both eyes through the filters at the stimulus object. The filters are set at zero, i.e., maximum brightness. The subject hears the noise of the motor but is often unaware of the fact that an episcotister is rotating between the eyepiece and the design he sees. He is asked to describe what he sees and to name the color of the design. The filter is then rotated about 80°, thereby changing the color of the circles from light green to red. The filter is returned to the zero setting, and the subject is asked to indicate at which point the color change from green to red is completed. On our instrument the lowest reading of one subject was 40° while others gave readings between 75° and 80°. The majority of readings lay between 50° and 70°.

Observations to be published in detail have shown the a.i.d.b. to be influenced by fatigue, cerebral anoxia, and pharmacological agents. A.i.d.b. also changes with the age of the individual. Children before puberty and some patients with mental disorders may show qualitative deviations and may be unable to see the complementary color. Patients with convulsive disorders seem to possess certain characteristics with regard to their susceptibility to negative afterimages. A certain relation between critical flicker fusion frequency (e.f.f.f.) and afterimage disappearance brightness seems to exist, but there is little doubt that the e.f.f.f. and a.i.d.b. measure two different functions of the perceptual apparatus.

The theory of afterimages is still under discussion. The instrument described here could certainly be improved. It provides, however, for the first time, a means to study objectively some aspects of a complex problem.

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## A Preliminary Investigation of the Relationship between Visual Fusion of Intermittent Light and Intelligence

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The evidence that critical flicker frequency is a centrally limited phenomenon is so strong, it seems possible that it may furnish a method for the study of some aspects of the central nervous system in its natural habitat. Halstead (3) presented evidence that the point of fusion is related to other central phenomena, but is not related to visual acuity. Misiak (4, 5) reported that the point of fusion for individuals is not related to visual acuity, varies with age above 30 years in a manner very similar to the raw scores of the Wechsler-Bellevue Intelligence Test, and does not improve with practice. Halstead, however, found only low correlations between his flicker-fusion frequency scores and scores on two intelligence tests. These correlations, nevertheless, were positive.

Halstead's apparatus employed a 10-μsec light flash. For frequencies of the magnitude reported by Halstead—approximately 20 cycles/sec—a 10-μsec flash means that the light-dark ratio was 1:5,000. Bartley (6) reported that the subjective brightness of intermittent light varies with frequency at frequencies below fusion in such a manner that brightness could very easily have functioned as a confusing variable. For light-dark ratios of 1:1 or greater, the subjective brightness becomes greater as frequency increases until the alpha frequency of brain waves is reached, and then decreases until it reaches the Talbot level at the point of critical flicker frequency. Subjective brightness reaches at its maximum a level that is about as far above that of a steady stimulus of an equivalent intensity as the Talbot level is below. Only an experimental study could determine the extent to which subjective brightness may have been a confusing factor in Halstead's study.

A second factor in Halstead's study that may have affected his findings was the fact that the frequency of the stimulus was varied by the observer. To what extent, if any, such a procedure influences the determination of a subjective phenomenon such as flicker-fusion is not known, but it may have been significant.

Bartlett (1) reported that, for an intermittent stimulus, the duration of the shortest noticeable dark interval becomes shorter as the length of the light flashes<sup>1</sup> increases, becoming a constant for light flashes longer than some critical duration. This suggests that measures of the critical point of fusion of intermittent light may have more meaning for such studies as Halstead's if the light-dark ratio of the stimulus is large.

This paper is a preliminary report of the relationship between several measures of visual fusion and test scores on the A.C.E. Psychological Examination, College Edition. The measures of visual fusion employed cover a wide range of light-dark ratios, running from less than 1-4 to approximately 200-1. The technique employed is to measure the shortest noticeable dark interval for a given length of light flash. It was thought that four flash durations ranging from 8 to 84 ms in an approximate geometric progression would offer a representative sample of the phenomenon of visual fusion for the purposes of this study. The results for this range were of such a nature that it was deemed advisable to add two longer flash durations to the investigation. It is to be noted that the measures of the duration of the shortest noticeable dark intervals are reciprocally related to frequency measures, and consequently negative correlations in this study would correspond in direction to the positive correlations in Halstead's study.

Electronic apparatus was used (7). The timing circuits consisted of two single-cycle multivibrators triggering each other to furnish continuous operation. One controlled the light time per cycle, and the other, the length of the dark time. The circuits operated an electronic switch that permitted a gas discharge light to present an intermittent stimulus. The intensity of the light was constant. Both time intervals were calibrated by picking up the actual light output with a photoelectric tube and observing the output on an oscilloscope, the sweep of which was driven by a Dumont low-frequency time base generator. Normally the apparatus presents no stimulus, but by the operation of a single spring switch the experimenter can present either a steady or an intermittent stimulus. The light source was placed in a dark viewing tunnel, when the only opening was the eyepiece against which the subject's face fit tightly. The stimulus source was 36 in. from the subject's eyes and subtended a visual angle of 1°.

The procedure consisted of a preliminary period of moderate dark adaptation, followed by determinations of the shortest noticeable dark intervals made by a method of serial explorations. Toward the end of a 5-min period during which he looked into the viewing tunnel, the subject was told that there would be a series of light stimuli 5 sec in duration—separated by rest periods of 15 sec, to maintain a reasonably constant level of adaptation throughout the experiment. The subject was required to judge whether each of the stimuli was flickering. He was given no indication of the procedure, nor of the proportion of stimuli that would actually be flickering.

The experimenter operated all the controls. For each

<sup>1</sup> The term "light flash" is used in this report to refer to the light fraction in a single cycle of a repetitive stimulus.

setting of light flash duration an exploratory procedure from flicker to fusion was first followed. During this procedure the dark interval was changed in large steps from stimulus to stimulus. When the approximate point of fusion was located, a series from fusion to flicker and one from flicker to fusion were run, the dark period being changed in small steps. The first changed responses in each of these two series were averaged, and this was considered the shortest noticeable dark interval for that length of light flash. In order to make it possible to investigate four light flash durations at a single sitting without introducing an element of fatigue, only one determination was made for each length of light flash.

TABLE I  
CORRELATIONS BETWEEN VISUAL FUSION AND A.C.E.  
RAW SCORES OF 25 MALE STUDENTS AT  
UNIVERSITY OF FLORIDA

Light flash duration for which fusion measured	Quantitative score	Language score	Total score
8 ms	-.063	-.190	-.182
16 "	-.211	-.127	-.193
38 "	-.236	-.156	-.233
84 "	-.434	-.060	-.264

In the first study (6), the shortest noticeable dark intervals were determined for each of the 25 subjects for light flash durations of 8, 16, 38, and 84 ms, in that order. In the second study, determinations were made for 21 subjects for light flash durations of 38, 84, 135, and 250 ms, in that order. In the second study there were two changes of significance. The light flash was reduced in intensity by the introduction of a filter. Also, subjects were tested only in the morning, a detail that was not considered in the first study. Because of the change in intensity of the light flash in the second group, it was not deemed advisable to combine the two groups. The results are shown in two tables of correlations, Table 1 representing the results of the first study.

The highest correlation between the shortest noticeable dark intervals and the Q-Score is for a light flash of 84 ms. It is significant at the 5% level of confidence. However, all the coefficients are negative, and there are definite trends toward increase in the magnitude of the coefficients with an increase in length of light flash for both Q-Score and Total Score. The question arose as to the possibility of this trend continuing with a further increase in the length of light flash, and to answer this in the second study, light flashes of 38, 84, 135, and 250 ms were used, in that order. By using this order, it could be determined whether the high values previously obtained for the 84-ms flash were to be attributed to the absolute length of the flash or to some type of learning on the part of the subjects.

The second study was conducted entirely with morning appointments, and then only when the subjects had eaten breakfast at least an hour in advance. Observation of the scatter diagrams of the data from the first study

showed that the correlations might have been considerably higher had it not been for three subjects. Interviews revealed that one of them had not eaten breakfast at the time of testing, whereas the other two came direct from afternoon naps. Table 2 shows the results of the second study. Only one of the subjects was tested in both groups.

TABLE 2

CORRELATIONS BETWEEN VISUAL FUSION AND A.C.E.  
RAW SCORES OF 21 MALE STUDENTS AT  
UNIVERSITY OF FLORIDA

Light flash duration for which fusion measured	Quantitative score	Language score	Total score
38 ms	-.405	-.515	-.513
84 "	-.478	-.532	-.485
135 "	-.114	-.161	-.147
250 "	-.121	-.172	-.147

Here there are five correlations significant at the 5% level of confidence, and again all the coefficients are negative. It is very interesting to note that light flashes longer than 84 ms do not yield increasingly higher correlations between A.C.E. scores and measures of visual fusion. In this second study, however, the correlations for the 38-ms interval are of the same general magnitude as those for flashes of 84 ms. The L-Scores and Q-Scores do not show the differences which occurred in the first study.

Because time often appears as an exponent in equations describing certain energy relationships,<sup>2</sup> there is the possibility that the relationships under consideration may not be linear. Logarithmic transformations of the data were made, and coefficients of correlations were calculated between (1) A.C.E. scores and logarithms of visual fusion measures, (2) logarithms of A.C.E. scores and visual fusion measures, and (3) logarithms of A.C.E. scores and logarithms of visual fusion measures. In general, resulting correlations were higher than the linear relationships, particularly for the Q-Scores and T-Scores, but the differences were not great.

The correlations between the visual fusion measures for the 84-ms light flash and the A.C.E. scores are strikingly high in view of the homogeneity of the groups studied—namely, college students representing a highly selective group in range of intelligence. It is probable that results for a more heterogeneous group would show even better correlation. In view of the order of determinations of the measures of visual fusion, the results indicate that the relationship was not a function of learning.

The writer is considerably puzzled, however, by the way the coefficients increase with the increase in the length of light flash up to 84 ms and then decrease with a further increase in length of light flash. The shortest noticeable dark intervals averaged 2.75 ms for the 84-ms light flash in the first group, and 6.44 ms in the second study, the

<sup>2</sup> The charge of a condenser at any time is expressed by the equation  $V = E_0(1 - e^{-t/RC})$ .

difference being attributed to the change in intensity. The total time for a cycle is such that the frequencies represented are within the range of the alpha frequencies of brain waves.

From the results of this experiment, it may be concluded that the shortest noticeable dark period for a light flash of some critical length promises to be a significant physiological correlate of intelligence. It must now be studied for a larger and more heterogeneous group, and be compared to performance on standard intelligence tests and other physiological variables.

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### Studies on the Mechanism of Nitrate Assimilation in *Neurospora*

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Although studies concerned with the assimilation of nitrate by plants have indicated the complex nature of this reduction process, in no case has the chemical mechanism involved been clearly demonstrated (see reviews by Burström [3], Street [12], and McKee [9]). Available evidence indicates that the process is enzymatically catalyzed, but there is no general agreement as to the nature of the products of this reduction (4, 13, 15). Granick and Gilder (5) demonstrated the importance of a porphyrin in the reduction of nitrate to nitrite by *Hemophilus influenzae*, and other studies have implicated molybdenum (10) and manganese (2). (See, however, Araon [1].) The actual site and mechanism of action of these metals are at present unknown.

In an effort to gain greater insight into the process of nitrate assimilation it appeared that the technique of genetically blocking specific chemical steps would prove fruitful, not only in identifying the intermediates in this chain of reactions, but also in demonstrating catalytic components of the system. Over 100 mutant strains of *Neurospora crassa* (microconidial—Tatum), obtained in this laboratory, were unable to grow on nitrate as a sole nitrogen source. These were tested for their ability to utilize nitrite and ammonia. It was found that several mutants which fail to utilize nitrate can grow normally when supplied with nitrite. By mixing these mutants, two at a time, in a liquid basal medium containing only nitrate nitrogen, it was possible to show that there are

at least three distinct mutant types which affect nitrate reduction (mutants A16, 2006, and A361). Growth on nitrate can be obtained by inoculating a nitrate medium with any two of these cultures, an observation indicating that under conditions of heterokaryosis what one mutant lacks another can furnish. Unfortunately it has not been possible to do genetic studies on these strains. Similar heterokaryon tests on mutants which fail to utilize nitrite indicate that there also exist at least three distinct mutant types affecting this step, namely 1896, 2003, and UV392. Heterokaryon formation between any of these two allows growth on the nitrite medium.

#### *Physiological studies on the individual mutants*

A nitrate basal medium supplemented with a synthetic vitamin mixture, with yeast extract, or with a concentrated dialyzate of the wild type *Neurospora*, would not support growth of mutants A16, A361, and 2006. There was likewise no growth of either mutant A16 or 2006 on a nitrate medium to which was added either a filter-sterilized extract of wild type mycelium grown on nitrate, or a concentrate of an ammonia plus nitrate medium upon which A16 or 2006 had been grown for 3-4 days. However, when these two mutants are grown on a nitrate basal medium (supplemented with a small amount of nitrite) in the same flask but separated by a dialyzing membrane, it is apparent from the enhanced growth of A16 that some diffusible growth factor lacking in A16 is produced by strain 2006. The converse, however, has not been observed. Further studies along these lines are in progress, as well as studies on the reduction *in vitro* of nitrate with mixtures of extracts from these three mutants.

In studies made with mutants 1896, 2003, and UV392, it was observed that UV392 would grow on a nitrite or nitrate basal medium when supplemented with yeast extract (5-10 mg/20 ml of basal medium). This growth-promoting factor in yeast extract is also present in the wild type *Neurospora* extract, from which it can be removed by dialysis. Since it permits the growth of UV392 on a nitrite medium, the factor acts catalytically. Extensive tests indicate that it is not one of the known vitamins or an intermediate of the Krebs-Szent-Györgyi cycle. The nitrite medium supplemented with various concentrations of *Neurospora* trace element solution likewise fails to promote growth. The new growth factor is at present being isolated and purified from yeast extract.

#### *Mutants affecting the utilization of ammonia*

If the mechanism by which nitrate is assimilated does not involve ammonia as a necessary intermediate, such as has been postulated by Burström (3) and others, it should be possible to obtain genetic blocks which inhibit the utilization of ammonia but which do not affect the utilization of nitrate. It has been possible to obtain mutants (Nos. 41, 43, 17) which are unable to grow on Fries ammonia minimal medium, but can still utilize nitrate or nitrite. This evidence strongly suggests that in the reduction of nitrate or nitrite, the intermediates are coupled and reduced as an organic compound, the product of whose reduction is an amino compound, R-NH<sub>2</sub>, which then transfers the amino group by transamination, or some similar process, thus bringing about the syn-

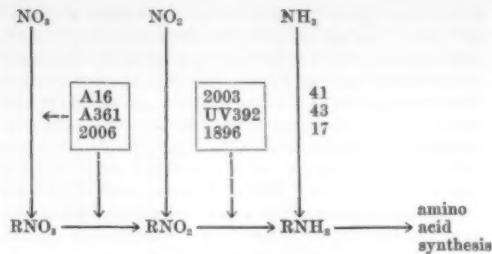


FIG. 1.

thesis of amino acids. These observations are also supported by the work of Marthaler (8), who found that *Epilobium angustifolium* can use nitrate, but not ammonia, as a source of nitrogen for growth.

The results of the present investigation, along with the observations of others, would suggest tentatively (Fig. 1) the pathway of nitrate, nitrite, and ammonia utilization in *Neurospora*. The sites of the various blocks are indicated.

The identification of the postulated organic intermediates must await additional experimental evidence. As the work of Lemoigne et al. (6, 7), Virtanen and Csáky (14), and Wood et al. (16, 17) suggests, it is possible that an oxime of oxaloacetate or  $\alpha$ -ketoglutarate is an intermediate in the assimilation of nitrite. Tests of the above-mentioned mutants with these oximes are under way at the present time. Suggestive evidence relating to problems of transamination and nitrate and ammonia utilization has come from the work of Stokes et al. (11) on the pH mutant of *Neurospora* requiring pyridoxine. These workers demonstrated that a block in the synthesis of pyridoxine can in some way affect the utilization of nitrate and ammonia differentially. It is possible that further work along this line would implicate pyridoxine or its phosphate derivative in the scheme of nitrate utilization.

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# A New Hemolytic Agent for the Manometric Determination of the Oxygen Content of Blood

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It has been the experience of a number of investigators that some samples of saponin currently available are inadequate as hemolytic agents for the estimation of the oxygen content of whole blood by the manometric method (<sup>2, 3</sup>). It has been found desirable to substitute a solution of 0.25% Aerosol<sup>2</sup> for the saponin. The working

Determinations of the oxygen content of blood samples were made as shown in Table 1. Lack of a supply of satisfactory saponin has made it impossible to compare results obtained with Aerosol and saponin reagents. Aerosol, however, has given consistently higher values than were obtained with the urea-albumin reagent (<sup>2</sup>) (Table 1, A). The blank obtained with the Aerosol reagent was uniformly low and stable (0.8–1.0 mm at 2.0 ml gas volume), indicating that no oxygen was liberated from the reagents. Reduced blood prepared as in the carbon-monoxide method of gas analysis (<sup>1</sup>) gave blank values of 0.22 vol % oxygen in three experiments, indicating that no significant amount of oxygen was liberated from blood components other than oxyhemoglobin.

Various concentrations of Aerosol were tried and satisfactory results obtained with concentrations of 0.10% and 0.25% Aerosol (Table 1, B). Higher concentrations (5% and 2.5%) produced a gel with blood which interfered with the reading of the meniscus.

TABLE 1

BLOOD OXYGEN VALUES OBTAINED WITH 0.25% AEROSOL AND OTHER REAGENTS

Sample No.	Oxygen content (vol %)		
	0.25% Aerosol	Urea-albumin reagent	% difference
Section A			
1	16.00	15.08	-5.8
2	14.39	13.82	-4.0
3	14.27	13.42	-6.0
4	9.36	8.78	-6.2
5	15.13	14.81	-5.4
Section B			
	0.25% Aerosol	5% Aerosol	
1	15.48	15.28	-1.5
2	15.23	14.81	-2.8
	0.25% Aerosol	2.5% Aerosol	
1	10.36	9.17	-11.5
2	16.00	15.33	-2.9
	0.25% Aerosol	0.5% Aerosol	
1	13.46	13.39	-0.6
2	12.56	12.40	-1.3
	0.25% Aerosol	0.1% Aerosol	
1	17.02	17.03	+0.1
2	18.60	18.65	+0.3
3	11.13	11.09	-0.4
4	6.78	6.82	+0.6
5	6.30	6.28	-0.3

reagent is prepared daily by diluting one vol of 1% Aerosol with 3 vol of 0.8% potassium ferriyanide. The stock Aerosol is stable, as satisfactory results have been obtained from solutions stored for a year. Duplicate analyses with a variation of less than 0.05 vol % oxygen on samples of 1 ml of blood are more easily obtained with the Aerosol reagent than with satisfactory grades of saponin because of the cleaner-working and more thorough emulsifying properties of the Aerosol.

<sup>1</sup>The technical assistance of W. I. Jones is gratefully acknowledged.

<sup>2</sup>Aerosol OT, 100% pellets, is dioctyl sodium sulfosuccinate, a product of the American Cyanamid and Chemical Corporation.

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## Radioautographs of Frog Membrane<sup>1</sup>

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In connection with problems arising from previous work (<sup>1</sup>) on the permeability of frog membrane, it became desirable to study the mode of ion passage through this membrane. In carrying out this investigation, a reliable method for making radioautographs of frog membrane was developed and is given in the following procedure: Highly radioactive sections of whole frog skin were prepared by exposing the morphological inner surface of a freshly excised membrane to solutions of labeled NaI (<sup>131</sup>I) for 4 hr. The radioactive solution assayed approximately 10<sup>6</sup> cpm/ml, as determined by depositing aliquots on filter strips 1 cm × 5 cm. The filter strips were counted by placing them lengthwise in closest proximity to an Eck and Krebs counter tube. The active membrane was fixed in Bouin's solution 2 hr, and was then treated according to the following schedule:

70% ethyl alcohol	60° C	30 min
96% ethyl alcohol	60° C	30 min
100% ethyl alcohol	60° C	30 min
50% ethyl alcohol		
50% acetone	25° C	5 min
100% acetone	25° C	15 min
100% xylol	25° C	15 min
100% paraffin	60° C	3 hr

<sup>1</sup>The isotope used in this research was obtained on allocation by the U. S. Atomic Energy Commission.

<sup>2</sup>Now with Whitmoyer Laboratories, Myerstown, Pa.



FIG. 1. Radionautograph of frog membrane obtained using  $I^{131}$ , showing sievelike penetration of the membrane by  $I^-$ . Magnification 100 $\times$ . Staining was with methylene blue.

The embedded section was blocked in paraffin, and sectioned to a 10- $\mu$  thickness on a Bausch and Lomb microtome. The sections were floated onto microscope slides from warm water placed in Petri dishes. After deparaffinizing 5 min in each of three successive baths of xylol, xylol, and absolute alcohol, the sections were stabilized by dipping in a 1% solution of Mallinckrodt's Parlodion in alcohol ether. The slides so prepared were coated in the darkroom (under a Wratten safelight) by spreading

on melted lantern slide emulsion. Slides that counted 930 cpm when placed in closest proximity to a thin-window (2.9 mg/cm<sup>2</sup>) counter tube gave relatively dense exposures in 8 hr. Generally, however, the optimum exposure time had to be determined empirically. The exposed slides were developed according to procedures recommended by Eastman Kodak for their emulsion. The developed slides were dried, stained with methylene blue when desired, and then mounted as usual.

These investigations revealed that there was no selective avenue of penetration of frog membrane by iodide ion. Reference to Fig. 1 shows that the membrane is penetrated as though it were a sieve. While resolution could be improved by suitably modifying the general procedure, it can be seen that there is no evidence that the glands, for example, are a route taken preferentially by iodide ion.<sup>8</sup> Fig. 2 is a typical radioautograph, which shows unusual concentration of iodine at the keratinized layer of cells (upper surface of section). This was a general finding, and was unexpected, since in every case the opposite membrane surface was the one exposed to the highly radioactive solution. This localization has been tentatively interpreted as indicating that either iodide ion is selectively adsorbed by the keratinized cells, e.g., the constituent proteins of these cells are more easily iodinated than other cells, or that the inert layer of cells acts as a barrier to the passage of iodide ion.

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<sup>8</sup> It is worthy of suggestion that the sievelike penetration is due to the relatively few layers of cells of each type which comprise the membrane.

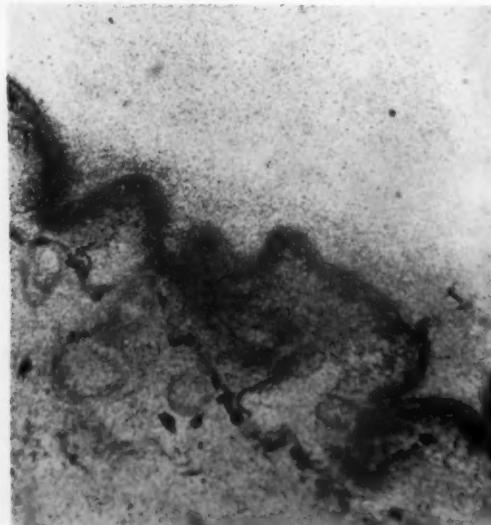


FIG. 2. Radionautograph of frog membrane obtained using  $I^{131}$ , showing concentration of iodine at the keratinized cells. Magnification 100 $\times$ . Staining was with methylene blue.

## Action of Bacterial Toxins on the "Fragility" of Chicken Erythrocytes<sup>1</sup>

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The effect of a number of toxins on the oxygen consumption of chicken erythrocytes has been reported in a preceding paper (<sup>8</sup>). As the next step in an initial survey of the action of bacterial toxins on cells, measurements were made of the osmotic behavior of chicken erythrocytes exposed to these same toxins. Although it is well known that many pathogenic bacteria produce hemolytic toxins, few studies have been made of the prehemolytic changes brought about by them.

<sup>1</sup> This work was supported in part by grants from the Division of Grants and Research, U. S. Public Health Service, and the Faculty Research Fund, University of Oklahoma.

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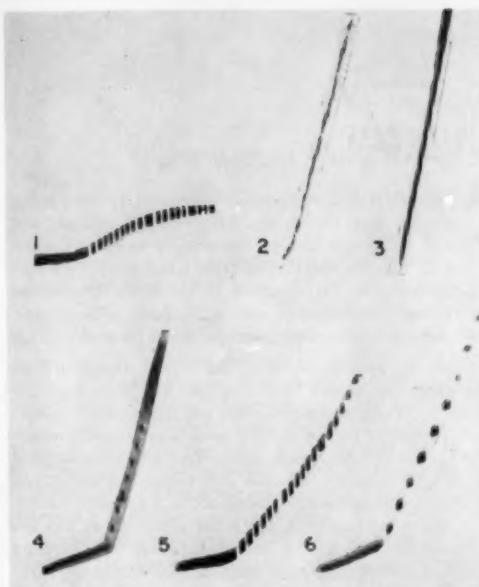


FIG. 1. Effect of bacterial toxins on the swelling of chicken erythrocytes in a solution of 0.3 M glycerol in Locke-Ringer. (1) Locke-Ringer control; (2) *Clostridium perfringens*, 0 min after mixing; (3) *M. aureus*, 7 min after mixing; (4) *B. cereus*, 157 min after mixing; (5) *S. pyogenes*, 10 hr after mixing; (6) *C. diphtheriae*, 24 hr after mixing. Breaks in curves 2 and 3 are second intervals; 15-sec intervals in other curves.

Certain enzymes present in toxins might be expected to alter the cell surface. For example, MacFarlane *et al.* (9-11) and Crook (4) concluded that a lecithinase in the toxins of *Clostridium welchii* is responsible for its lethal, hemolytic, and necrotizing actions. The toxins produced by *Bacillus cereus* also contain a lecithinase (3). Forsman (5) concluded that the action of staphylococcal lipase was enzymatic, and Christie and Graydon (2) demonstrated the presence of a lipase in staphylococcal toxins. Bernheimer (1) and Wilbrandt (12) both suggested that some toxins produce a change in the membrane of erythrocytes that makes them cation-permeable, leading to hemolysis.

Measurements were made using the photoelectric apparatus previously described (6), while the source of the toxins<sup>1</sup> and the general procedures were also previously indicated (8). The movement of a beam of light reflected from a Type R galvanometer, which recorded the changes in light transmitted by the erythrocyte suspensions as they changed volume, was recorded on 12-cm bromide paper. Stock suspensions were prepared by mixing equal volumes of chicken erythrocytes and (a) toxins, (b) broth, (c) Locke-Ringer's solution, (d) toxins plus 0.02 M formaldehyde (which had been mixed for longer than 2 months), and (e) preservatives. These stock suspensions were placed at 37° C. An aliquot (usually 0.1 ml) of each stock solution was removed im-

<sup>1</sup> The authors are indebted to the Lilly Laboratories and to the Lederle Laboratories for supplying most of these toxins.

mediately after mixing and was added to 10 ml of a solution of 0.3 M glycerol in Locke-Ringer in the chamber of the photoelectric apparatus. The change in the amount of light transmitted by the suspension was recorded. Sterile precautions were observed except during the few minutes these measurements were made. The course of toxin action was followed by removing aliquots from the stock suspensions at subsequent times, up to 46 hr in one experiment. Locke-Ringer, formalized toxins, broth, Locke-Ringer + 1:10,000 merthiolate, and Locke-Ringer + 1:20,000 phenyl mercuric acetate were the controls used. The last two demonstrated that the preservatives in the toxins had no influence on the measurements in these experiments, and the broth and formalized toxins gave essentially the same results as the Locke-Ringer controls.

Typical results, presented in Fig. 1, show that the toxins of *Clostridium perfringens* (strength unknown) affect the cells immediately; while the toxins of *M. aureus* (15,000 dermal necrotic doses/ml) have a marked effect almost immediately; while the toxins of *B. cereus* (strength unknown), of *Streptococcus pyogenes* (strength unknown), and of *Corynebacterium diphtheriae* (800 MLD for guinea pig/ml) have respectively less and less effect. Exposures of chicken erythrocytes to the toxins of *Clostridium septicum* (160 MLD for mouse/ml) for 22 hr, and to the toxins of *C. tetani* (300,000 MLD for guinea pig/ml) for 46 hr have no effect.

The swelling technique used in these experiments was designed to measure permeability but, as was pointed out by Hunter (7), other changes in the cells frequently interfere with the interpretation of such records. The large galvanometer deflections shown in the figure, obtained with all but the control cells, are a consequence of hemolysis of some of the cells, resulting from an increase in their "fragility." Thus it can be said that some of these toxins do alter the surface of the cells, so that some of them hemolyze following shrinking and swelling. Whether or not their permeability to glycerol has been altered cannot be determined from these observations. It is interesting to note that those toxins which contain a lecithinase (*C. perfringens* and *B. cereus*) and a lipase (*M. aureus*) are the most effective in altering the cell surface. The streptococcal toxin used in these experiments was primarily the scarlatinol fraction, which explains why its action was not more marked.

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## Book Reviews

*Progress in the Chemistry of Organic Natural Products*, Vol. V. L. Zechmeister, Ed. Vienna, Austria: Springer-Verlag; New York: Walter J. Johnson, 1948. 417 pp. \$11.20 unbound; \$12.00 bound.

Volume V of *Progress in the Chemistry of Organic Natural Products* gives the impression that it is written in German, but this is true only of the first chapter; the rest are in English. Since it was published in Vienna, the excellence of the typesetting and proofreading in what is a foreign tongue to the men and women of Springer-Verlag is remarkable.

This is essentially a series of review articles on various topics which have in common only that they deal with the organic chemistry of naturally occurring compounds of somewhat complicated structure. Carotenoids, azulene derivatives, glycerides, poly- and oligosaccharides, lignins, toad venoms, and fish proteins are discussed. The reader is made familiar with the more important of the recent work in each field. A chapter on the chemistry of genetics and one on determination of structure by infrared spectroscopy complete the volume.

The list of authors reads like a *Who's Who* in these fields and suggests what a careful reading confirms, that the topics are treated with finesse and judgment. Only relatively trivial adverse criticisms can justly be made. On page 14, the semipolar structure of a 3-atom epoxy structure seems unacceptable by modern concepts. The term "ultraviolet light" is employed, whereas "light" is properly confined to visible radiation. On page 186 degree of polymerization is improperly defined. The formula for 8-methoxydihydrobenzopyrone on page 209 contains a hydrogen atom where there should be a double bond. On page 213 the elm tree is called *Populus nigra*, which is a species of poplar, including the familiar Lombardy poplar as subspecies. "Euryhaline" is defined on page 286 after being introduced on page 267. That horror of organic chemists, the quinquevalent carbon atom, appears on page 360.

This volume is indispensable to workers in the various fields covered, but this reviewer wishes also to recommend it to those in other fields of organic chemistry who have a curiosity about the world around them. Have you wondered why a lobster turns from green to red when it is cooked? Just how voracious sandworms are, or how the protein of fish differs from other protein? How the fatty acids are distributed on the glycerol residues in a fat? Whether there are 23 or 24 chromosomes in the human male spermatozoon? If so, you will enjoy reading and studying this book.

H. B. HASS

General Aniline and Film Corporation

*The Effects of Atomic Weapons*. Prepared for and in cooperation with the U. S. Department of Defense and the U. S. Atomic Energy Commission under the direction of the Los Alamos Scientific Laboratory. Samuel Glasstone, Ed. Washington, D. C.: U. S. Government Printing Office, 1950. 456 pp. \$1.25. (Clothbound editions available from commercial publishers.)

Since the announcement of the atomic explosion over Hiroshima, the atomic bomb has been a favorite topic for authors. Some writing has had relatively little thought or information behind it, and some was sheer nonsense. The present volume should remove the limitations imposed by lack of accurate technical information on the effects of atomic explosions upon personnel and materiel.

In reviewing this book, one is inevitably drawn to comparisons with the Smyth Report, to which it is to some extent a sequel. Here is none of the historical background nor any discussion of the long-range effects of the weapon upon civilization unprepared to deal with it. The over-all phenomenology associated with atomic explosions in the air, at the ground surface, under the ground, and under water are discussed in detail. The results of measurements made at the various field tests are supplemented by theoretical calculations. Two chapters are devoted to medical effects and methods of personnel protection. As with the Smyth Report, one is amazed and gratified at the amount of information it has been possible to release from the cloak of security.

Much of the information contained in this volume is badly needed for intelligent planning of defenses against atomic weapons, although a rather considerable technical background will be required to make full use of the material. There is some uncertainty as to the audience for which this book was planned. At one point the text explains that 1 kilogram is equivalent to 1,000 grams, and at another the integrals of the Planck radiation theory are used freely. In general, the text accompanies the mathematical treatments with physical explanations, so that a serious but nontechnical reader can obtain at least a qualitative idea of the phenomena involved.

The authenticity of the work is unquestioned, for the list of authors is practically a *Who's Who* of atomic bomb phenomenology. As a group they have been responsible for understanding and evaluating the effects of atomic explosions upon personnel and materiel. They have made an important contribution in collecting and interpreting their results and making them available to the general public.

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## *News and Notes*

### The 15th Cold Spring Harbor Symposium on Quantitative Biology: Origin and Evolution of Man

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This year's symposium, held June 9-17 at the Biological Laboratory, Cold Spring Harbor, Long Island, New York, brought together students of fossil man, physical and social anthropology, race, constitution, and human and general genetics. Investigators from Brazil, Denmark, England, Germany, India, Japan, Italy, and Sweden were among those present. Approximately 94 of the participants remained in residence at Cold Spring Harbor for part or all of the conference, and about 35 others registered as nonresident participants.

The program was arranged by the geneticist Th. Dobzhansky, of Columbia University, and the anthropologist S. L. Washburn, of the University of Chicago. M. Demerec, director of the Biological Laboratory, served as chairman.

The first day was devoted to general discussions of "Population as a Unit of Study." It was followed by two days' treatment of the "Origin of the Human Stock" and "Classification of Fossil Men." "Genetic Analysis of Racial Traits," including the frequencies and distribution of inherited diseases, of normal mor-

phological traits, and of the various blood-group systems, was dealt with on the three following days. On the seventh day, "Race Concept and Human Races" was considered; on the eighth day, "Constitution;" and at the final meeting, "Perspectives of Future Research." Each paper was followed by lively discussion, and the proceedings of the day were summarized by the session chairmen.

The conference was witness to the convergence of anthropology and genetics. The meetings were not so much a mutual education as a mutual consideration of problems of common concern. The speed in the spread of knowledge from one field to the other, and the bearing of contemporary studies in basic general genetics on problems in the special field of anthropological genetics, as well as the stimulus from the latter field to thinking in the former, made the symposium a most satisfactory experience.

The publication of the papers, discussions, and summaries will place before a wider circle a very useful outline of the present status of our knowledge of the origin, evolution, and differentiation of man.

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### Symposium on Copper Metabolism McCollum-Pratt Institute of The Johns Hopkins University

Bentley Glass

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The second annual symposium sponsored by the McCollum-Pratt Institute of The Johns Hopkins University was held June 15-17 at the institute, in Baltimore, Maryland. Fifty-three chemists from the United States, Australia, and New Zealand participated. Because copper is an essential requirement for plants and animals alike, because it is known to be characteristic of a number of metalloprotein enzymes, because it is demonstrably deficient in certain types of soils, and, finally, because it was among the earliest known trace elements, it was chosen for the subject of the first of these symposia to be devoted to a particular micronutrient element. The 17 papers presented at the symposium ranged over the plant, animal, and soil relationships of copper, and exemplified the chief methods of experimental attack upon the problem of a micronutrient's role in nutrition. In certain studies the effects of a deficiency of the element

were investigated; in others, an analysis of enzymes was carried out, first to determine which ones are metalloprotein in nature, and thereafter to determine precisely which of the latter contain the element in question—copper.

The sessions of the first day began with a consideration of those properties of copper which affect its formation of organic complexes (A. H. Corwin), and then turned to the status of studies on the copper-protein enzymes—ascorbic acid oxidase (C. R. Dawson), the tyrosinases of animals (Frank Mallette), and the corresponding phenol oxidases of plants (John M. Nelson). An important new theory, derived from the study of the reaction catalyzed by ascorbic acid oxidase, was described, namely, that the copper in the enzyme, divalent to start with, shuttles reversibly back and forth between the divalent and monovalent states during catalysis, and that exchange of the copper occurs only when the copper in the enzyme is

monovalent. In the last paper of this session, the relations between the browning of foods and the activity of copper-proteins were considered (John B. Thompson).

On the second day of the symposium two papers were presented dealing with the copper metabolism of invertebrate animals. After a general survey of this field (Vincent Dethier), the occurrence, evolution, and properties of hemocyanin were examined in more detail (Alfred C. Redfield). These papers were followed by a series that dealt with copper in nutritional studies of mammals. An introductory account of the use of radioactive copper in nutritional studies (C. L. Comar) was followed by an illustration of its use in analyzing the influence of copper on the metabolism of phosphorus and molybdenum in Florida cattle (George K. Davis). The effects of a copper deficiency in Australian sheep (H. R. Marston) were contrasted with those seen in New Zealand sheep and cattle (I. J. Cunningham). It was particularly interesting that the stringy wool of copper-deficient Australian sheep could be connected with a greatly diminished oxidation of cysteine to cystine in the wool; so that the copper enzymes, like the cytochrome system, may serve as terminal oxidases for the -SH groups, too. This session was well-rounded by a consideration of copper metabolism in human subjects (G. E. Cartwright). Although copper deficiencies are scarcely to be expected in persons on normal diets, yet there are many indications that copper is important in human metabolism.

The sessions of the third day were devoted to copper metabolism in plants and its relation to soils. The chemical nature of the copper complexes formed in peat soils and plants was described (Jeffrey E. Dawson), and followed by significant analyses of the effects of trace elements and phosphate in the nutrition of herbage plants on South Australian soils (H. C. Trumble), and of the

distribution of mineral nutrients in forage plants of North Carolina in relation to varying soil conditions and geologic age of the soils (Kenneth C. Beeson). A survey of the copper nutrition of green plants and fungi (Robert A. Steinberg) was followed by a further consideration of the functional aspects of copper in plant metabolism (D. I. Arnon). This final paper brought together much evidence to indicate that the copper enzymes play a role alternative or supplementary to that of the cytochrome system as the terminal oxidases that make the use of molecular oxygen in respiration possible, and also presented new evidence that copper may be the metal (or at least one of the metals) concerned in the light reaction of photosynthesis in green plants.

As a whole, the symposium was stimulating and marked by lively discussion. The close and informal association of the participants for three days helped to make the meeting fruitful. It became clear that such studies as these of enzyme functions in metabolism and their relations to specific micronutrients such as copper, and, in turn, the bearing on both of these of the analyses of soils with respect to multiple trace elements, and the climatic, topographic, geologic, and ecologic relationships of the animals and plants and people living on those soils have tremendous significance for the future. They make possible a new type of environmental control that will permit the development of lands naturally unproductive. In an age when the world's food problem is becoming increasingly acute few enterprises can offer more promise. This copper symposium represents a beginning in the synthesis of knowledge from many fields that is needed to make such an undertaking feasible.

The full proceedings of the symposium, together with the discussions and a more detailed summation, will be published in book form by the Johns Hopkins Press.

## About People

**Roger Adams**, head of the Chemistry Department, University of Illinois, has been elected member of the Board of Overseers of Harvard University. The overseers, elected by the alumni, compose one of two boards that direct Harvard policies.

**William A. Altemeier**, assistant professor of surgery in the University of Cincinnati College of Medicine, has been appointed a member of the National Research Council. Dr. Altemeier will serve three years on NRC's Division of Medical Sciences as a representative of the American Surgical Association.

**Arthur Gerard DeVoe**, of the Institute of Ophthalmology, Presbyterian Hospital, New York City, has been appointed professor and chair-

man of the Department of Ophthalmology at New York University's Postgraduate Medical School, a unit of the New York University-Bellevue Medical Center. Dr. DeVoe will have charge of all ophthalmological teaching, research, and patient care at the medical center, and will direct Bellevue Hospital's eye service.

**Stanford Moore**, associate member of the Rockefeller Institute for Medical Research, is on leave of absence for a year, to hold the Franequi Chair in the School of Medicine, University of Brussels.

**Joseph M. Pisani** has been appointed executive director of the Committee on Medical Sciences of the Research and Development Board, to succeed James E. McCormack, who will become associate dean of New York University's Postgrad-

uate Medical School, in September. Dr. Pisani, deputy executive director of the committee since September, 1949, will be succeeded in that position by **Thomas B. Spencer**, Rochester, New York, physician.

Recent appointments to the staff of the Los Alamos Scientific Laboratory are: **Richard E. von Holdt**, instructor in mathematics, Northwestern University; **Frank C. Hoyt**, director of the Theoretical Physics Division, Argonne National Laboratory; **Alice H. Armstrong**, professor of physics, Wellesley College; **William C. Dickinson**, Massachusetts Institute of Technology; **Richard L. Henkel**, student at the University of Wisconsin; **John H. McQueen**, instructor in physics, University of Virginia; and **R. E. Peterson**, graduate teaching assistant in physics, University of Wisconsin.

## Visitors

**Muhiddin Erel**, professor of hygiene and director of the Institute of Hygiene, University of Istanbul, Turkey, is working in the Laboratory of Microchemistry, Teaneek, New Jersey, studying recent microchemical procedures as applied to various problems in hygiene and nutrition.

**J. Ganguly**, Indian biochemist, is a postdoctoral fellow in the Department of Biochemistry, University of Southern California, Los Angeles. Dr. Ganguly, who took his Ph.D. at the University of Reading, England, as a Government of India scholar, will work for a year at USC on the metabolism of carotenoids.

## Grants and Awards

**The George R. Henderson Medal** of the Franklin Institute, Philadelphia, has been awarded to Paul Walter Kiefer, of the New York Central Railroad, for contributions to the railroad equipment field. The medal will be presented on October 18 at the Franklin Institute.

**The Atomic Energy Commission** has made grants totaling \$23,980 to the University of Tennessee School of Biological Sciences, to finance 6 research projects until July 1, 1951. Studies using radioactive calcium to determine the factors influencing the absorption and metabolism of calcium will be carried on under the direction of Edward F. Williams, Jr., associate professor of chemistry. A study of the mechanics of influenza virus infections, using radioactive sulfur, will be directed by John L. Wood, associate professor of chemistry, and Douglas Sprunt, chief of the Division of Pathology and Bacteriology. Lester Van Middlesworth, instructor in physiology, will investigate the effect of anoxia on the thyroid gland and study the processes taking place in damaged tissues undergoing repair. Study of the mechanisms responsible for changes in cell membrane permeability and disturbances in ionic balance will be under the direction of R. R. Overman, associate professor of physiology. The effects of radioactive iodine on cancer and other diseases of the thy-

roid will be studied by Dr. Sprunt, Carl E. Nurnberger, assistant professor of radiology, and Aly N. Lipscomb, instructor in medicine. Research in the use of radioactive ruthenium in treatment of superficial lesions will be undertaken by David Carroll, instructor in radiology, Joseph Cara, resident in radiology, and Dr. Sprunt.

**The Alvarenga Prize for 1950** has been awarded to Ephraim Shorr, associate professor of medicine, Cornell University Medical College, for his work in shock, which has provided a clearer understanding of the mechanism of this condition. The prize was established by the will of Pedro Francesco DaCosta Alvarenga, of Lisbon, Portugal, an associate fellow of the College of Physicians of Philadelphia, and is awarded annually by the college.

## Fellowships

**The Garnsey Research Fellowship** was recently established at the School of Tropical and Preventive Medicine, Loma Linda, California. The fellowship provides a stipend for a student working toward his M.S. or Ph.D. in medical zoology.

Four teaching fellowships in chemistry, biology, physics, and psychology are available at Brandeis University, Waltham, Massachusetts. Recipients of the fellowships, designated as the **Sara N. Stonehill Memorial Teaching Fellowships**, will be selected on the basis of a national competition. They will teach on a part-time basis at the university and also continue with their graduate studies in the Boston area.

**The American Association of University Women** announces that 19 national fellowships, open to American women for study in the U. S. or abroad, and 8 international fellowships for women in other countries, are available for 1951-52. In general, the fellowships will be awarded to candidates who have completed two years of residence work for the doctor's degree, or who have already received the degree, but the project on which the candidate wishes to work, its significance, and evidence

of ability to pursue the study will be the most important criteria. Detailed information concerning the fellowships may be obtained from the Secretary, Committee on Fellowship Awards, AAUW, 1634 Eye Street, N.W., Washington, D. C. Applications must be filed by December 15.

## Colleges and Universities

**Rutgers University's Bureau of Engineering Research** has been conducting studies of the irregularities of atomic arrangement in solids, under the direction of Alfred J. Reis, research specialist in the bureau. The work, sponsored by the Office of Naval Research, involves use of a double x-ray spectrometer developed at the university, which can produce very accurate and complete pictures of the irregularities of atomic structure. This research will help to determine the maximum strength of industrial materials and whether present products can be improved.

**The University of Texas' Department of Aeronautical Engineering** has established a new degree program, leading to the bachelor of science degree in meteorology, to start in September. A brochure outlining the new curriculum in detail and including course descriptions and other information can be obtained by writing Kenneth H. Jehn, Assistant Professor of Meteorology, Engineering Building 133, University of Texas, Austin 12.

**The University of Chicago's Oriental Institute** will soon send an expedition to northeastern Iraq, for further study of the site of Jarmo, a village that the "atomic calendar" developed by W. F. Libby, professor of chemistry of the university's Institute for Nuclear Studies, indicates may be 7,000 years old. Discovered by accident in 1946, it was very briefly studied three years ago. Preliminary diggings revealed evidence of the use of cultivated grains and utensils for grinding them. Flint tools were also found, as well as bone fragments of farm animals that were either domesticated or in the process of becoming so. Under the direction of Robert J. Braidwood, associate professor

of Old World prehistory and anthropology, the expedition will remain at the site from September 1, 1950, to May 15, 1951. Mrs. Braudwood, who is also a member of the institute staff, will accompany the expedition.

## Meetings

More than 1,000 mathematicians are expected to attend the first International Congress of Mathematicians to be held since 1936. It will meet at Harvard University, August 30-September 6, under the sponsorship of the American Mathematical Society. The program will include four conferences and a number of invited addresses. Conferences will be held on algebra, topology, analysis, and applied mathematics, at which groups of specialists will present surveys of their respective fields. Ten-minute talks by any members of the congress who wish to discuss their own work will also be given. The invited addresses will be 60-minute talks by distinguished mathematicians on their own discoveries. Field Medal awards will be made, two to go to young mathematicians for outstanding work. The first Field awards were made at the Oslo Conference in 1936.

The first official international mathematics congress was held in Zurich in 1897, although a preliminary gathering was held at Northwestern University in 1893. The second was held in Paris in 1900, and after that a congress was held every four years (1916 excepted) until 1940, when the meeting was postponed because of the war.

The International Union Against Tuberculosis will hold its 11th World Congress, September 3-6, in Copenhagen. The 10th congress was held in 1937, although the Council and the Executive Committee have both held annual meetings during the past three years. K. A. Jensen, of the University of Copenhagen's Institute of General Pathology, will preside over the congress, and speakers from 19 countries will take part in the scientific sessions. The National Tuberculosis Association and its medical section, the American Trudeau

Society, will be represented by Edmund Long, director of research and therapy for the society, and Kirby S. Howlett, Jr., past president of the ATS. Their respective subjects will be sensitivity and resistance of the tubercle bacillus to chemotherapeutic agents, and collapse therapy. Several other U. S. physicians will take part in the panel discussion on tuberculosis control measures on the closing day of the meeting.

The American Society of Mechanical Engineers will hold its fall meeting at Hotel Sheraton, Worcester, Massachusetts, September 19-21. Some 50 papers will be read at 24 technical sessions on heat transfer, management, rubber and plastics, textiles, power, machine design, safety, gas turbine power, fuels, hydraulics, materials handling, production engineering, metals engineering, and wood industries. Speakers will include James R. Killian, Jr., president of Massachusetts Institute of Technology; Nathan Tufts, vice president of the New England Box Company; Luigi Broglio, professor of structures at the Graduate College of Rome and visiting professor at Purdue University, whose subject will be "The Method of Equivalence Applied to Engineering and to Mathematical Physics"; Ludwig F. Musil, professor at the Technischen Kochschule and technical manager of Steirische Wasserkraft und Elektrizitäts, at Graz, Austria, who will speak on the trend of power plant practice in Germany.

An eight-week course in neuroanatomy, sponsored by the New Jersey Physical Therapy Association, will begin September 27 at the Kessler Institute for Rehabilitation. The course will be given by Charles Noback, of the Neurological Division, College of Physicians and Surgeons, Columbia University. The lectures will be held on Wednesday evenings from 8:00 P.M. to 10:00 P.M. and are open to physicians and to physical, speech, and occupational therapists. Registration fee for the entire course is \$15; single lectures are \$2. Further information may be obtained from Miss Genevieve Reilly, Chief Physical Therapist, Kessler Institute, West Orange, New Jersey.

## Miscellaneous

A nine-man board of judges to choose the two winners of the \$2,000 fifth annual AAAS-George Westinghouse Science Writing Awards has been announced. Awards of \$1,000 each will go to the writer of what the judges consider the best news story and the best magazine article on science published during the 1950 contest year in a newspaper and in a general-circulation, nontechnical magazine. Both awards will be presented December 28 during the Annual Meeting of the AAAS in Cleveland, Ohio.

The judges of the science writing competition, chosen to represent the general public, science, newspapers, and magazines, are: Morris Meister, principal of the Bronx (New York) High School of Science and past president, National Science Teachers Association; Henry R. Aldrich, secretary, Geological Society of America; Detlev Bronk, president of The Johns Hopkins University, chairman of the National Research Council, and president of the National Academy of Sciences; Norman Cousins, editor, *Saturday Review of Literature*; John R. Dunning, dean of the Faculty of Engineering of Columbia University; Rudolph Flesch, readability consultant; Charles C. Hemerway, editor, the Hartford (Connecticut) *Times*; Hillier Kriegbaum, professor in the New York University School of Journalism; and Howard A. Meyerhoff. Dr. Meister is chairman of the board of judges.

Seventeen newspaper science writers have been honored in the past in the competition, and are no longer eligible for the \$1,000 newspaper award. They are: Howard W. Blakeslee, Associated Press; Watson Davis, Science Service; David Dietz, Scripps-Howard newspapers; Thomas R. Henry, Washington *Star* and North American Newspaper Alliance; Waldemar Kaempffert, New York *Times*; Gobind Behari Lal, *American Weekly*; William L. Lawrence, New York *Times*; Herbert B. Nichols, *Christian Science Monitor* and the U. S. Geological Survey; John J. O'Neill, New York *Herald Tribune*; Robert D. Potter, writer and consultant; Jane Stafford, the

late Frank Thone, and Majorie Van de Water, all of Science Service; James G. Chesnutt, San Francisco *Call-Bulletin*; George Keaney, New York *World-Telegram*; Frank Carey, Associated Press; and Lester Grant, New York *Herald Tribune*.

Past winners of the magazine award, and not eligible to compete again in that division are: Steven M. Spence, *Saturday Evening Post*; Florence Moog, St. Louis writer and scientist; and George W. Gray, freelance writer of Sparkill, New York.

The awards were established in 1946, the centennial year of the birth of George Westinghouse, to stimulate the interest of the general public in the role of science in the world today, and to encourage young writers to enter careers in science writing. The awards, administered by the AAAS, are made possible by a grant from the Westinghouse Educational Foundation.

In accordance with a formal agreement concluded between Unesco and the International Council of Scientific Unions in December, 1946, the Council and the International Scientific Unions it federates began to receive grants-in-aid from Unesco in 1947. At the end of 1949 they had received grants-in-aid for exactly 3 years, and a report on the results obtained has been presented to the Executive Board for critical examination and review.

In April, 1947, the board approved the allocation of \$235,977 for grants-in-aid to the International Council of Scientific Unions (ICSU), its federated unions, and their international scientific organizations. Subsequently, the director-general authorized a further grant of \$4,171, and in December, 1947, the board authorized supplementary grants-in-aid amounting to \$15,962, totaling \$256,130 in the field of natural sciences in 1947. The total for 1948 was \$238,374; for 1949, \$256,426.

Distribution of the allocated grants-in-aid, according to the different groups of sciences, for 1949, is as follows: General sciences (including the history of science), 24.5%; physicochemical sciences, 37.4%; astronomy and earth sci-

ences, 18.2%; and biological sciences, 19.9%.

The results achieved by the grants-in-aid are really much more far-reaching than the dry figures listed indicate. They have hastened the resumption of international cooperation in the field of natural sciences after the war. Even now, scientists in most countries find it exceedingly difficult to obtain foreign exchange for traveling expenses, either to attend international meetings or to work for a short period in other countries. Some international services were without adequate funds; some international laboratories and stockrooms were in need of essential equipment. Unesco's grants-in-aid to the international nongovernmental organizations for 1947 arrived in time to meet these urgent needs and facilitate the revival of international cooperation in the natural sciences.

Not only Unesco, but also working scientists throughout the world, believe that the subventions granted to international symposia and to publications will go a long way in the promotion of international understanding and in the advancement of scientific knowledge.

Organizations receiving grants-in-aid in 1949 were:

International Council of Scientific Unions  
International Union of Pure and Applied Physics  
International Astronomical Union  
International Union of Scientific Radio  
International Union of Crystallography  
International Union of Theoretical and Applied Mechanics  
International Union of Chemistry  
International Geographical Union  
International Union of Geodesy and Geophysics  
International Union of Biological Sciences  
International Zoological Station at Naples  
International Association of Microbiologists  
International Union of the History of Science  
International High Altitude Station at Jungfraujoch

**Synthetic mica** has been produced in substantial quantities at the Colorado School of Mines as the result of a 4-year research project, under

grant from the U. S. Signal Corps. Cakes of mica, weighing up to 500 pounds, have been formed by a new "cool hearth" method that eliminates the use of crucibles. Crystallization takes place in a basin of unmelted raw mixture of pure potassium silicofluoride, silica, alumina, and magnesia. This material, forming the hearth of the furnace, moves about 1 inch per hour under the heat of a natural gas flame. Melting occurs on the leading edge, crystallization on the trailing end, of the molten pool. The development of the traveling hearth and the elimination of the use of crucibles are considered the School of Mines' most important contributions to the project. William A. Aitkenhead, former assistant professor of metallurgy at the Colorado School of Mines, and recently named director of the Mining Research Laboratory at Washington State College, Pullman, has directed the project for the past year.

Medical and radiology authorities representing the U. S. atomic energy project are visiting the British Atomic Energy Establishment at Harwell, England, this month. They are: Shields Warren, director, Division of Biology and Medicine, AEC, Washington, D. C.; Robley D. Evans, professor of physics, Massachusetts Institute of Technology; Gioachinni Failla, Department of Radiology, Columbia University; Jacob Furth, chief, Pathology Section, Biology Division, Oak Ridge National Laboratory; Joseph G. Hamilton, co-director, Medical, Physics, and Biology Divisions, Radiation Laboratory, Berkeley, California; Alexander Hollaender, director, Biology Division, Oak Ridge; Leonidas D. Marinelli, Radiological Physics, Argonne National Laboratory; Leslie F. Nims, chairman, Biology Department, Brookhaven National Laboratory; Robert S. Stone, Medical School, University of California, San Francisco; Lauriston S. Taylor, chief, X-Ray Section, National Bureau of Standards; Paul C. Aebersold, chief, Isotopes Division, AEC, Oak Ridge Operations Office; and Logan Emlet, superintendent, Operations Division, Oak Ridge.

Drs. Warren, Failla, Taylor, Ham-

ilton, and Evans will continue discussions held last September with British and Canadian representatives, on standards of radiation tolerances, at the Canadian Atomic Energy Establishment, Chalk River, Ontario.

Radiation-absorbing glasses that protect the eyes against atomic rays have been developed by University of Pittsburgh chemists through research directed by Alexander Silverman, head of the university's Department of Chemistry.

One glass is a high-energy x-ray or gamma-ray absorbing glass containing tungsten phosphate. Its radiation-absorbing power is 50% greater than that of previously existing x-ray shielding glass. It was developed by Joseph J. Rothermel and Kuan Han Sun. The other glass is a slow-neutron absorbing glass containing cadmium borosilicates with fluorides. Work on this glass was done by Label Melnick, Hurd W. Safford, and Kuan Han Sun.

The new glasses are of immediate importance to workers in atomic

energy, atomic bomb, and hydrogen bomb plants to prevent radiation cataracts, from which some workers have already suffered (P. H. Abelson and P. G. Kruger, *Science*, 1949, 110, 655) and should prove useful for heavy transparent laminated peepholes in the safety barriers in atomic energy plants. Goggles containing laminated lenses for both x-ray and neutron absorption are a possibility for civilian protection in atomic or hydrogen bomb warfare.

Improved methods of blood separation will be sought in a program administered by the American Red Cross under a contract with the Atomic Energy Commission. The primary interest of the AEC in blood-fractionation studies is the development of means for separation and preservation of white blood cells and platelets, which are of particular value in combating acute radiation effects. The Red Cross hopes to develop new and quicker methods for obtaining and preserving plasma and red blood cells, so that stockpiles of blood constituents will be available

in the event of atomic disaster. None of the AEC funds will be used to finance the Red Cross National Blood Program, nor does the contract provide for establishing blood banks.

The Bureau of Mines, U. S. Department of Interior, has published *Review of Literature on Health Hazards of Beryllium and its Compounds* (Information Circular 7473), by G. G. Morgis, research assistant in the bureau's Health Branch, and J. J. Forbes, chief of the Health and Safety Division. The circular reviews industrial health hazards resulting from the handling of beryllium and its compounds and discusses ways of controlling them. Free copies may be obtained by writing the Publications Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13.

## Make Plans for—

**Illuminating Engineering Society**, national technical conference, August 21-24, Pasadena, California.

**American Veterinary Medical Association**, annual meeting, August 21-24, New Municipal Auditorium, Miami Beach, Florida.

**American Crystallographic Association**, summer meeting, August 21-25, New Hampton School, New Hampton, New Hampshire.

**National Shade Tree Conference**, annual meeting, August 21-25, Hotel Syracuse, Syracuse, New York.

**International Northwestern Conference on Diseases of Nature Communicable to Man**, August 23-25, University of Washington, Seattle.

**Plant Science Seminar**, 27th annual meeting, August 24-30, Massachusetts College of Pharmacy, Boston.

**American Congress of Physical Medicine**, annual meeting, August 28-September 1, Hotel Statler, Boston.

**Third Conference on Reaction Mechanisms in Organic Chemistry**, August 29-September 2, Northwestern University, Evanston, Illinois.

**Econometric Society**, August 30-September 6, Harvard University.

**Tissue Culture Association**, meeting August 31-September 2, Cooperstown, New York.



Scientists of the Smithsonian Institution, National Park Service, and the Bureau of Reclamation at work at the Angostura Reservoir, near Hot Springs, South Dakota. One of the most significant yet found in the survey of areas soon to be flooded by reservoirs, the site is so deeply buried that it has been necessary to use bulldozers. Stone Javelin heads have been found that are similar to, although not identical with, Yuma points, which immediately succeeded the Folsom point, one of the earliest known implements made by man in the New World. Part of the same project are other excavations going on at the Garrison Reservoir and at the site of the first Fort Randall, both in the Dakotas.



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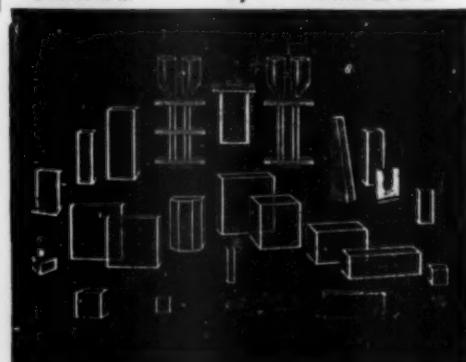


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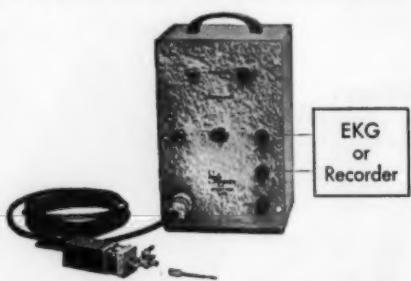
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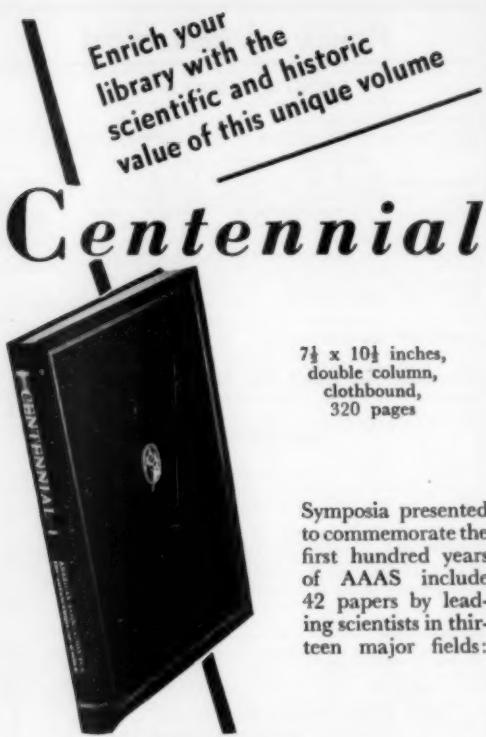
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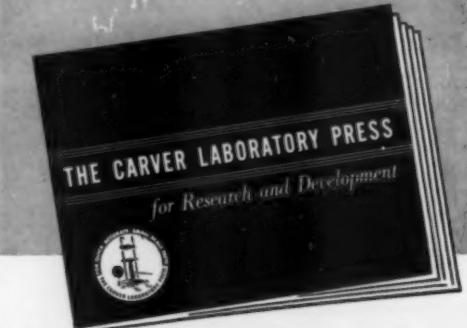
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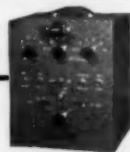
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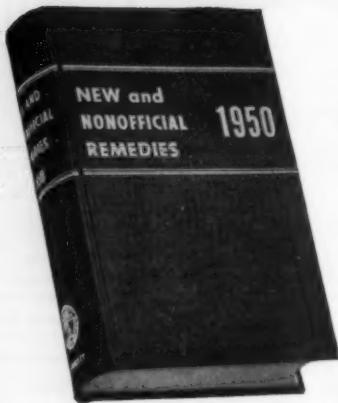
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